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YAKIMA RIVER SPRING CHINOOK ENHANCEMENT STUDY

Annual Report 1989

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YAKIMA RIVER SPRING CHINOOK ENHANCEMENT STUDY

Annual Report FY 1989

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1.0 ACKNOWLEDGEMENTS

We would like to thank all the members of the Yakima Indian Nation Fisheries Resource Management staff for their suggestions and assistance in the field. Thanks also to Joe Jay Pinkham III, William Fiander, Joe Hoptowit and the late Matt Goudy, Jr. for maintaining the high quality of data collected in the field. Additional part-time personnel who assisted in the collection of data were Steve Thompson, Leroy Senator, Hollis Woodward, Tammy Swan, Beverly Dogsleep, Bobby Bobb, Thomas Morrison, Dean Payer, Paul Wahpat, Virgil Lewis, Karl Braden, Vern Bogar, Ed Comenout, William DeCoteau and Tom Benson.

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2.0 ABSTRACT

Smolt outmigration was monitored at Wapatox on the Naches River and Prosser on the lower Yakima. The spring outmigration at Wapatox was estimated to be 19,332 smolts. The 1989 winter and spring outmigration of wild spring chinook from the Yakima Basin was estimated to be 20,672 and 88,996 smolts respectively past Prosser.

The survival from egg to smolt was calculated using the 1987 redd counts and the 1989 smolt outmigration at Prosser. The estimated survival was 1.17%, which gives a mean egg to smolt survival over seven years of 4.0%.

In 1989 a total of 4,115 adult and 244 jack spring chinook salmon returning to the Yakima River were counted at Prosser fish ladder. This gives a total of 4,359 salmon returning to Prosser Dam. The median dates of passage were May 15 and May 24 for adults and jacks respectively. An additional 560 fish were estimated to have been caught in the Yakima River subsistence dipnet fishery below Horn Rapids and Prosser Dams. Therefore, total return to the Yakima system was 4,919 spring chinook salmon.

Spring chinook were counted at Roza Dam from April 1 to September 29, 1989. Counts at Roza Dam were 3,548 adult and 208 jack spring chinook for a total of 3,756 wild fish. However, fall-back of adult spring chinook (9 of 19) at Roza Dam was documented during a radio

tracking study (Berman 1989) indicating that actual passage is significantly lower. The median dates of passage at Roza Dam were June 1 and June 13 for spring chinook adults and jacks respectively.

The smolt to adult (S_{sa}) survival will be calculated when scale analysis from spawner surveys is complete. Spring chinook adults from ten different experimental release groups were recovered in 1989. A total of 143 coded wire tags were recovered.

3.0 INTRODUCTION

The population of Yakima River spring chinook salmon (*Oncorhvnchus tshawvtscha*) has been drastically reduced from historic levels reported to be as high as 250,000 (Smoker, 1956). This reduction is the result of a series of problems including mainstem Columbia dams; dams within the Yakima itself; severely reduced flows due to irrigation diversions; outmigrant loss in irrigation canals; increased thermal and sediment loading: and overfishing. Despite these problems, the escapement of spring chinook to the Yakima River has continued at levels ranging from 166 to 9,442 since 1957.

In October, 1982, the Bonneville Power Administration contracted the Yakima Indian Nation to develop methods to increase production of spring chinook in the Yakima System. The Yakima Nation's current enhancement policy attempts to maintain the genetic integrity of the spring chinook stock native to the Yakima Basin. Relatively small numbers of hatchery fish have been released into the basin in past years. Data from the Wenatchee System indicate a return rate from hatchery smolts of less than .25% (Mullan, 1982). Return rates from the current Yakima study smolt releases are .07%. These low return rates indicate that few fish would have returned from these early hatchery releases.

Thus the genetic input from hatchery fish into Yakima Basin stocks is probably negligible.

The goal of this study is to develop data that will be used to formulate management alternatives for Yakima River spring chinook. The study has five major objectives. The first objective is to determine the distribution, abundance and survival of wild Yakima River spring chinook. Naturally produced populations are being studied to determine if these runs can be sustained in the face of presentharvestand environmental conditions. Survival through each life stage is being evaluated in an attempt to determine limitations to natural production in the basin. Survival to emergence studies have been conducted to determine survival through the incubation stage. Analysis of the relationship between survival to emergence and gravel substrate quality have been studied. Seining at selected sites and electroshocking surveys have been conducted to evaluate distribution and abundance of juvenile fish. Smolt outmigrations are monitored at the Wapatox juvenile trap on the Naches River, at Roza Dam juvenile trap in the mid Yakima River and at the Prosser juvenile trap on the mainstem Yakima River. Adult returns are determined by monitoring the Yakima Tribal dipnet fishery, counting adults at Prosser and Roza fish ladders, and through spawning ground surveys. Physical parameters such as water temperatures and stream flow are monitored throughout the basin.

The second major objective of this study is to determine the relative effectiveness of different methods of hatchery supplementation. This objective is divided into three sub-objectives:

a) Determination of optimal release time. Smolt releases are the norm, but fingerlings were released in June, September, and November of 1984 and 1985. Downstream survival of these smolts was evaluated and adult returns have been monitored.

b) Determination of optimal manner of release. In the past, fish have either been transported from a hatchery and released directly into the Yakima River, or raised in rearing ponds. These methods, as well as the use of acclimation ponds, are being evaluated.

c) Determination of optimal release stocks. Smolts were released in 1986 and 1987 as hatchery X hatchery (Leavenworth stock), hatchery X wild, and wild X wild crosses to determine the effect of genetic makeup on the success of various releases. Success will be measured as the number of adults returning from each of these release groups.

Adverse interactions between hatchery releases and wild stocks were minimized by scatter-planting hatchery fish so densities in the river remained low enough to minimize competition for food and space.

The last three major objectives of the study are:

3) to locate and define areas in the watershed which may be used for the rearing of spring chinook:

4) to define strategies for enhancing natural production of spring chinook in the Yakima River; and

5) to determine the physical and biological limitations on production within the system.

These objectives will be met at the end of the study when the database is complete.

This project is a multi-year undertaking that will evaluate differentmanagementand enhancement strategies. At the conclusion of this study, a series of alternatives will be developed that can be used to determine how best to enhance the runs of spring chinook in the Yakima Basin. Annual reports were presented for 1983 (Wasserman and Hubble, 1983), 1984 (Wasserman, Hubble, and Watson, 1985) 1985 (Fast, Hubble, and Watson, 1986), 1986 (Fast, Hubble, and Watson, 1986), 1987 (Fast, Hubble, and Watson, 1988) and 1988 (Fast, Hubble, and Kohn, 1989). A detailed description of methods and materials used in this study can be found in these earlier reports. This current report is concerned with new findings in 1989 and some re-evaluation of previous data in light of current information.

4.0 DESCRIPTION OF STUDY AREA

The Yakima River is located in Central Washington and flows 217 miles from its headwaters in the Cascade Mountains (elevation 2,448 ft) to the Columbia River near Richland at river mile (RM) 335 (Figure 1). The Yakima River Basin drains 6,155 square miles of the east slopes of the Cascade Mountains in Kittitas and Yakima Counties. The Yakima River flows east and souththroughthe Kittitas Valley from its ruggedly glaciated headwaters. South of the valley the river cuts through Manastash and Umtanum ridges in a deep canyon. The river enters the middle valley above Yakima through a gap cut in Selah Ridge and leaves through Union Gap in Ahtanum Ridge. Rattlesnake Hills, crossing eastern Yakima and northern Benton Counties, and the Horse Heaven Hills to the south are prominent features bordering the lower river in its 80 mile reach from Union Gap to the Columbia River. The Yakima River enters the Columbia River near Richland at an elevation of 300 feet.

The major tributaries, with the exception of Satus and Toppenish Creeks, enter the river above the city of Yakima. The Naches River is the largest tributary, entering the Yakima at RM 101 and extending 51 miles to the junction of the Bumping and Little Naches Rivers. The Naches River drains an area of 1,106 square miles. Other important tributaries of the Naches include the

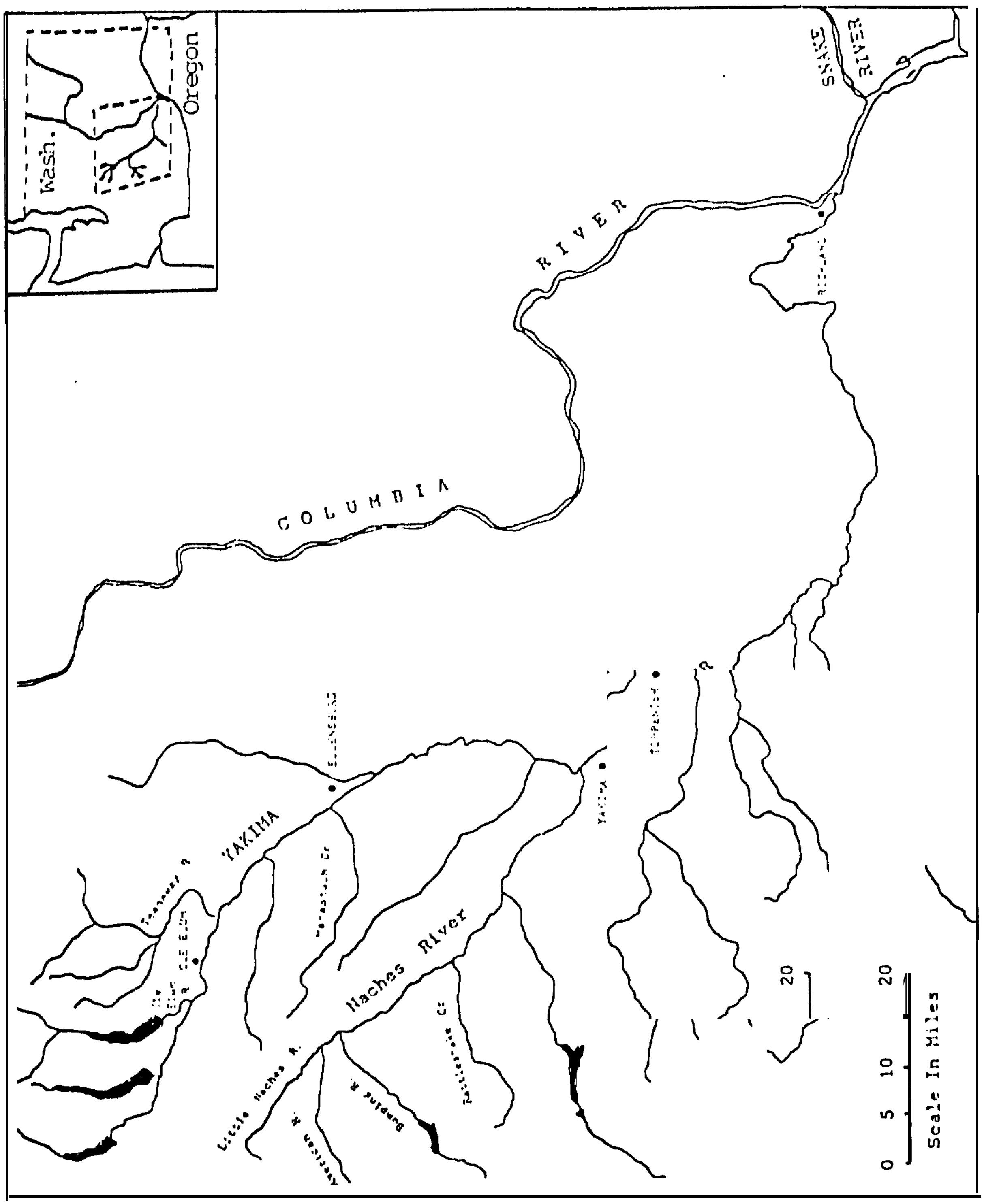

Figure 1. Study area on the Yakima River system.

American and Tieton Rivers and Rattlesnake Creek.

Important tributaries in the upper Yakima are the Teanaway and Cle Elum Rivers. Numerous creeks, including Manastash, Taneum, and Swauk, flow into the Yakima in the Kittitas Valley. The climate of the Yakima Basin varies from wet-alpine in the Cascade Mountains to semi-arid conditions at the lower elevations. The crest of the mountains receive 80 to 140 inches of precipitation per year while approximately one third of the basin receives ten inches or less. Summer temperatures average 55 F in the mountains and 82 F in the valleys. During the winter monthly maximum temperatures range from 25 F to 40 F and low temperatures range from -20 F to -25 F.

The Yakima River Basin produces 3.5 million acre feet average annual runoff, unregulated. The U.S. Bureau of Reclamation's Yakima Irrigation Project has transformed the semi-arid region into a productive agricultural region. Approximately 500,000 acres are presently under irrigation, consuming 2.25 million acre feet each year. There are numerous dams and irrigation diversions on the river. These include Horn Rapids, Prosser, Sunnyside, Wapato, Roza, and Easton. A screening structure is associated with each of these dams. For an extensive description of the Yakima Basin, see Bryant and Parkhurst (1950).

In the Yakima system, reservoir storage acts to regulate flows. Man-made Kachess, Keechelus, and Cle Elum Lakes in the upper Yakima and Bumping and Rimrock Lakes on the Naches system are the major storage sites. These storage areas supplement flows during the irrigation season (March-October) and store water in the winter. Irrigation and power diversions generally reduce flows in the lower sections of the Yakima River. Sunnyside and Wapato dams near rivermile 108 divert approximately one-half the total river flow at each site into irrigation diversions in the summer and fall. Prosser diversion removes approximately 1,400 cfs for irrigation and power production throughout most of the year. Due to the large irrigation diversions at Prosser and Parker, flows drop dramatically in the lower river from June to October. Approximately 50% of the flows withdrawn at diversion sites re-enter the river downstream after being used for irrigation or hydropower.

Prior to 1980, flows remained high on the spawning grounds in September and October for irrigation purposes. Many fish that spawned at this time deposited their eggs in shallow water near the bank. When flows were decreased at the end of the irrigation season, these redds were often dewatered. Following court action in 1981 the irrigation flows were decreased in the Yakima branch during the first week of September so that this problem would not continue. To offset the reduction of flows from the upper Yakima in September, flow is increased in the Naches River mainly from Rimrock Reservoir releases. The increased flows enter the Naches River below the areas of heavy spring chinook spawning and flows are not believed to impact spawning success.

5.0 METHODS AND MATERIALS

5.1. NATURAL PRODUCTION

5.1.2 PROSSER SMOLT TRAP

Prosser smolt trap was operated continuously from November 23, 1988 to July 13, 1989. Prossertrap operates from a bypass pipe that shunts fish from rotary drum screens in Chandler Canal back to the mainstem Yakima River. In 1984, 1985, 1986 and 1987 trapping efficiency (the percentage of outmiga -s passing Prosser Dam diverted into the trap) was cal ated via a series of releases of marked fish. The sta stical methodology for efficiency calculations was evaluated by Douglas Chapman of the University of Washington Center for Quantitative Science. A detailed description of the evaluation process can be found in Appendix B of the 1986 BPA annual report. The basic procedure was as follows. Once each week, fish captured in the trap during the night were cold-branded. Two groups were branded differently, with one group released two miles upstream of the canal intake, and the other in the canal. Efficiency (E_i) was based on the recapture rate of branded fish as follows:

$$E_i = \frac{C_{ri}}{R_{ri}\ (C_{ci}\ /R_{ci}\ )}$$

where E_i = fraction of fish diverted into the canal in the ith experiment;

R_{ci} = number released directly into the canal in the ith experiment:

R_{ri} = number released directly into the river in the ith experiment;

C_{ci} = number recaptured from the canal release in the ith experiment; and

C_{ci} = number recaptured from the river release in the ith experiment.

During the 1984, 1985, 1986 and 1987 spring chinook smolt migrations, a total of 68 separate efficiency tests were performed. A relationship was developed between the combined 1984-87 efficiency data and river discharge. This relationship was then used to estimate the total number of juvenile fish passing Prosser dam in each of the years the trap was operating. The confidence intervals for the calculated total smolt passage for each year was estimated from a linearized form of the logistic equation Y = l/l+E (-A+BX). Lengths, weights and scales were taken from random samples of all species and release groups on a daily basis. In addition unbranded ad-clipped hatchery spring chinook were sacrificed for coded wire tag analysis on a daily basis. Coded wire tags were implanted and adipose were removed on winter outmigrants.

5.1.2 WAPATOX

The purpose of Wapatox smelt trap on the Naches River is to monitor smelt outmigration in the spring and the pre-smolt outmigration the remainder of the year. Species monitored include spring chinook salmon, steelhead and rainbow trout and other resident trout species. Wapatox smolt trap is located on the Naches River at RM 17, just downstream from the confluence of the Tieton and Naches Rivers (Figure 1). The trap is constructed on the Wapatox by-pass ditch. Fish entering the canal are shunted into a by- pass pipe by a series of rotating drum screens across the diversion canal.

The 1988 fall monitoring season was initiated September 1 and ended November 23 when the screens in the canal were removed for the winter. The canal was dewatered for repairs from October 17 through November 4. Wapatox smolt trap continued operation beginning April 1, 1989 when the rotary drum screens were installed into the canal. Monitoring of the spring smolt outmigration extended through the month of June. Three periods of high river flow (April 14-25, May 05-15 and June 05-15) rendered the trap inoperable. During these periods daily catches were estimated from a linear regression of the mean daily catch 7 days preceeding and following the flooding events.

The trap was normally checked at least 4 times per week and more often during peak migration periods. Only salmonid species were enumerated. Fish were anesthetized with MS-222, fork lengths and weights were recorded, and scale, samples were taken from spring chinook smolts.

5.1.3 ROZA SMOLT TRAP

Roza juvenile trap was operated on a experimental basis beginning April 1, 1989 and continuing through the summer. A primary objective was to determine how effectively it could be used to monitor juvenile salmonid outmigration from the upper Yakima River. An inclined plane trap was fished in the fish bypass on a 24 hour basis. Fish are directed into the fish bypass system by a series of rotary screens in the forebay. Except for two periods (April 14-19 and April 28-30) the trap was monitored daily during the month of April. Beginning in May the trap was fished one day per week for a 24 hour period. Fish were removed from the livebox on an hourly basis and anesthetized with MS-222. After fish were identified according to species, fork lengths and scale samples were taken from a portion of each day's catch. No attempt was made in this, the initial year of operation, to establish a flow/entrainment relationship. This will be attempted in the spring of 1990.

5.1.4 ADULT RETURNS

Adult spring chinook salmon harvested below Prosser in the 1989 Yakima Tribal ceremonial dipnet fishery were monitored under the BIA 638 contract.

The Prosser and Roza Dam adult fish counting stations were monitored in 1989. Counting at Prosser began April 1 and continued through August. Roza Dam was monitored from May 1 through September 29. Water clarity at Roza Dam was such that fish swimming over the counting board could be visually examined for the presence or absence of an adipose fin. All adipose-clipped fish were collected in a second trap and sacrificed to recover the coded wire tags.

Spawning ground surveys were inititated on the American River in August under a contract from the Bonneville Power Administration. Spawning ground surveys were conducted throughout each reach of spawning area on a bi-weekly basis. All carcasses were examined for adipose fins, and lengths (fork length and mid-eye to hypural plate length) were recorded. Scale samples were taken, and gonads were examined to determine sex and egg retention in females. The tail of each fish was removed so it would not be examined more than once.

5.1.5 ESTIMATES OF SURVIVAL THROUGH VARIOUS LIFE STAGES

5.1.5.1 Egg to fry:

Total egg deposition was calculated as mean fecundity of Yakima River females (based on the length fecundity model) multiplied by the number of redds located on the spawning grounds.

The total number of fry produced (F) was calculated as:

F = mean fecundity of Yakima River spawners x number of redds x survival from egg deposition to emergence.

5.1.5.2 Egg to Smolt:

An index of survival from egg to smolt (S_{es}) was estimated with the following expression:

$$S_{es} = \frac{\text{estimated number of smolts at Prosser}}{\text{total egg deposition for brood year.}}$$

5.1.5.3 Fry to Smolt:

An index of survival from fry to smolt (S_{fs}) was estimated with the following expression:

$$S_{fs} = \frac{\text{number of smolts estimated to pass Prosser}}{\text{fry for brood year}}$$

Estimates of egg deposition and fry production for 1981through 1989 were based on redd counts from spawning ground surveys. Survival from egg to smolt and from fry to smolts were based on redd counts in the years 1981-1987 and smolt outmigration estimates (at Prosser) in the years 1983-1989.

5.1.5.4 Smolts to Adult:

The smolts to adult survival (S_{sa}) of wild spring chinook salmon in the Yakima system was based on the estimated outmigration at Prosser in the years 1983-1986 and the return of jacks (3 year old fish) and four and five year old adults corresponding to each years' smolt run. Returns are incomplete for outmigration later than 1986.

5.2 HATCHERY OPERATIONS

5.2.1 BROOD STOCK EVALUATIONS

Hatchery spring chinook introduced into the Yakima River from 1958 to 1987 have come from numerous sources and stocks (Table l), although, as previously mentioned, their contribution to the genome of naturally spawning Yakima River fish has probably been minimal. An experimental brood stock program was undertaken in 1984 and continued in 1985 to evaluate the benefits of using Yakima River spring chinook as broodstock. The purpose of this program was to compare the return rates of native, hybrid and non-native smolts.

The best stock for enhancement programs will be determined by a comparison of returns of adult fish from four release groups: (1) an acclimated group of hatchery-reared "natives" (Yakima males crossed with Yakima females), (2) a pond-acclimated group of hatchery-reared "hybrids" (Yakima River males crossed with Leavenworth Hatchery females), (3) an acclimated group of pure hatchery smolts (Leavenworth males crossed with Leavenworth females), and (4) a group of hatchery smolts (similar to group 3) but which were released directly into the river. Groups l-3 were allowed volitional release from an acclimation pond in the upper Yakima River. These groups will be used to determine if cultured fish that are the progeny of Yakima River spring chinook have a greater success in returning to the Yakima River than do non-native stocks. The fourth group will be used to estimate the value of acclimating spring chinook in ponds for various periods before allowing volitional release. Returns from group four will be compared directly to group three.

Table 1. Historical plants of spring chinook in the Yakima River Basin.

Brood year	Release date	Hatchery	Size fish/lb	Number released	Brood stock	Release Location
1958	8/59	Klickitat	143	20,000	Klickitat	Yakima River
1960	5/61	Leavenworth	330	18,000	Icicle	Yakima River
1961	2/62	Leavenworth	1000	5,000	Icicle	Yakima River
1962	12/62	Leavenworth	1000	5,000	Icicle	Yakima River
1962	63			12,500		Nile Springs
1963	64			10,000		Nile Springs
1971	6/73	Klickitat	58	162,400	Klickitat	Naches River
1971	6/73	Klickitat	58	162,400	Klickitat	American River
1974	75			8,500		Nile Springs
1974	4/76	Ringold	3	7,230	Ringold	Nile Springs
1974	9/76	Klickitat	29	42,775	Klickitat	Nile Springs
1975	3/77	Klickitat	19	13,300	Klickitat	Nile to Richland
1976	3/78	Klickitat	7	2,462	Cowlitz	Nile Springs
1977	4/79	Carson	20	50,000	Carson	Yakima River
1977	4/79	Klickitat	12	25,000	Cowlitz	Nile Springs
1978	4/80	Klickitat	10	24,000	Klickitat	Nile Springs
1978	4/80	Leavenworth	18	30,260	Carson	Yakima River
1979	4/81	Klickitat	14	33,616	Klickitat	Nile Springs
1979	4/81	Leavenworth	20	400,221	Leavenworth	Yakima River
1980	4/82	Leavenworth	14	100,050	Leavenworth	Nile Springs
1980	4/82	Leavenworth	15	401,714	Leavenworth	Yakima River
1981	4-5/83	Leavenworth	18	103,110	Leavenworth	Nile Springs
1981	4/83	Leavenworth	19	97,012	Leavenworth	Yakima River
1982	4/84	Entiat	19	29,636	Carson	Nile Springs
1982	4/84	Entiat	25	45,552	Carson	Yakima River
1983	6/84	Leavenworth	66	102,837	Carson	Yakima River
1983	9/84	Leavenworth	25	102,833	Carson	Yakima River
1983	11/84	Leavenworth	22	108,305	Carson	Yakima River
1983	4/85	Leavenworth	18	50,000	Carson	Yakima River
1984	6/85	Leavenworth	66	100,000	Leavenworth	Yakima River
1984	9/85	Leavenworth	25	100,000	Leavenworth	Yakima River
1984	11/85	Leavenworth	22	100,000	Leavenworth	Yakima River
1984	3/86	Leavenworth	21	51,846	Carson	Yakima River
1984	4/86	Leavenworth	20	50,657	Carson	Yakima River
1984	3/86	Leavenworth	17	46,476	Carson/Yakima	Yakima River
1984	3/86	Leavenworth	17	33,052	Yakima	Yakim River
1985	3/87	Leavenworth	21	50,519	Carson	Yakima River
1985	3/87	Leavenworth	17	50,113	Carson/Yakima	Yakima River
1985	3/87	Leavenworth	17	52,392	Yakima	Yakima River
1985	4/87	Leavenworth	20	56,841	Carson	Yakima River

Note: Native spring chinook broodstock in Klickitat River at time were supplemented with Carson, Cowlitz, Eagle Creek, and Williamette Fish.

5.2.2 ADULT HATCHERY RETURNS

Ten groups of adult hatchery fish returned to the Yakima River in 1989. Coded-wire tags were recovered from two sources: the adult trap at Roza Dam and the Yakima dip net fishery. All tags recovered were expanded by the sample rate (fish sampled/total number of fish caught for a fishery and by the mark rate or coded-wire tag retention rate.

Survival rate for hatchery smolt to adult was calculated by dividing the total expanded return of adults from each release by the estimated passage of smolts by Prosser from that release. The expanded return numbers were also divided by the total number of smolts released in each group to obtain a hatchery planting to adult survival rate.

6.0 RESULTS AND DISCUSSION

6.1 NATURAL PRODUCTION

6.1.1 PROSSER JWENILE FACILITY

Smolt outmigration was estimated from a logistic relationship between percent river diversion and percent entrainment (Fast et. al., 1985). A logistic relationship was fit to data from test releases made in 1984, 1985, 1986 and 1987. This relationship (Appendix B of the 1986 BPA annual report) was used to estimate 1989 outmigration. Test releases will be made throughout the duration of the project. The diversion-entrainment relationship will be refined and the outmigration of previous years re-estimated.

6.1.1.1 Winter Movement

The Prosser smolt trap was operated from November 23, 1988 through March 31, 1989 to monitor the winter migration of juvenile spring chinook and other salmonids. Atotalof 30,731 salmonids were estimated to have migrated past Prosser dam of which 20,672 were spring chinook. A weekly breakdown of spring chinook passage is presented in Table 2 and a daily breakdown is presented in Appendix C.l. - C.5.

Fifty-five point eight percent of the estimated spring chinook winter migration occurred from November

23 to December 31, 1988 (Table 2). In the winter of 1987-88 80.3% outmigrated during the same period. In 1988-89 the winter migration was more equally distributed temporally than in previous years, although the least movement was still observed in January and February. In the winters of 1986-87, 1987-88 and 1988-89 spring chinook winter migrations (previous to March 31) made up 26.2%, 22.1% and 18.8%, respectively, of the combined spring and winter outmigration. In the winter of 1987-88 the left pelvic fin was removed on 17.3% of the spring chinook passing the smolt trap. In the winter of 1988-89 coded wire tags (cwt's) were implanted in 59.0% of the winter outmigrants. The pelvic clip and cwt's will identify returning adults as winter migrants and will provide data for preliminary estimates on the contribution of winter migrants to production.

Thble2. Estimated outmigration of juvenile spring chinook at Prosser Dam November 23, 1988 through March 31, 1989.

Period of Estimation	Total Chinook
11/23/88-11/30/88	4,738
12/01/88-12/07/88	1,092
12/08/88-12/14/88	606
12/15/88-12/21/88	1,568
12/22/88-12/31/88	3,523
01/01/89-01/07/89	1,964
01/08/89-01/14/89	1,241
01/15/89-01/21/89	456
01/22/89-01/31/89	843
02/01/89-02/07/89	I.5
02/08/89-02/14/89	12
02/15/89-02/21/89	5
02/22/89-02/28/89	658
03/01/89-03/07/89	664
03/08/89-03/14/89	2,773
03/15/89-03/21/89	279
03/22/89-03/31/89	232
Total	20,669

Estimated passage based on interoplation: 12/15-20, 1/5-6, 2/2-22 and 3/10-16.

6.1.1.2 Spring Movement

Total estimated outmigration of spring chinook smolts is presented in Table 3. The Chandler juvenile facility was in operation from April 1 through July 13, 1989. Estimated outmigration of wild spring chinook smolts in the months April, May, and June were 51,368, 32,322, and 5,296 respectively. Ten spring chinook were counted the first13 days of July. Peak smolt outmigration occurred the week of April 8-14, when 20,530 smolts were estimated to have moved past Prosser (Figure 2). The median date of passage was April 25, 1989.

Table 3. Estimated spring outmigration of juvenile spring chinook at Prosser Dam from April 1, through July 13, 1989.

Period of Estimation	Total Chinook
04/01/89-04/07/89	3,187
04/08/89-04/14/89	20,530
04/15/89-04/21/89	14,337
04/22/89-04/30/89	13,314
05/01/89-05/07/89	20,397
05/08/89-05/14/89	7,004
05/15/89-05/21/89	3,080
05/22/89-05/31/89	1,841
06/01/89-06/07/89	4,459
06/08/89-06/14/89	677
06/15/89-06/21/89	100
06/22/89-06/30/89	60
07/01/89-07/07/89	10
07/08/89-07/13/89	0
Total	88,996

Estimated passage based on interoplations: 04/16/89 and 04/23/89.

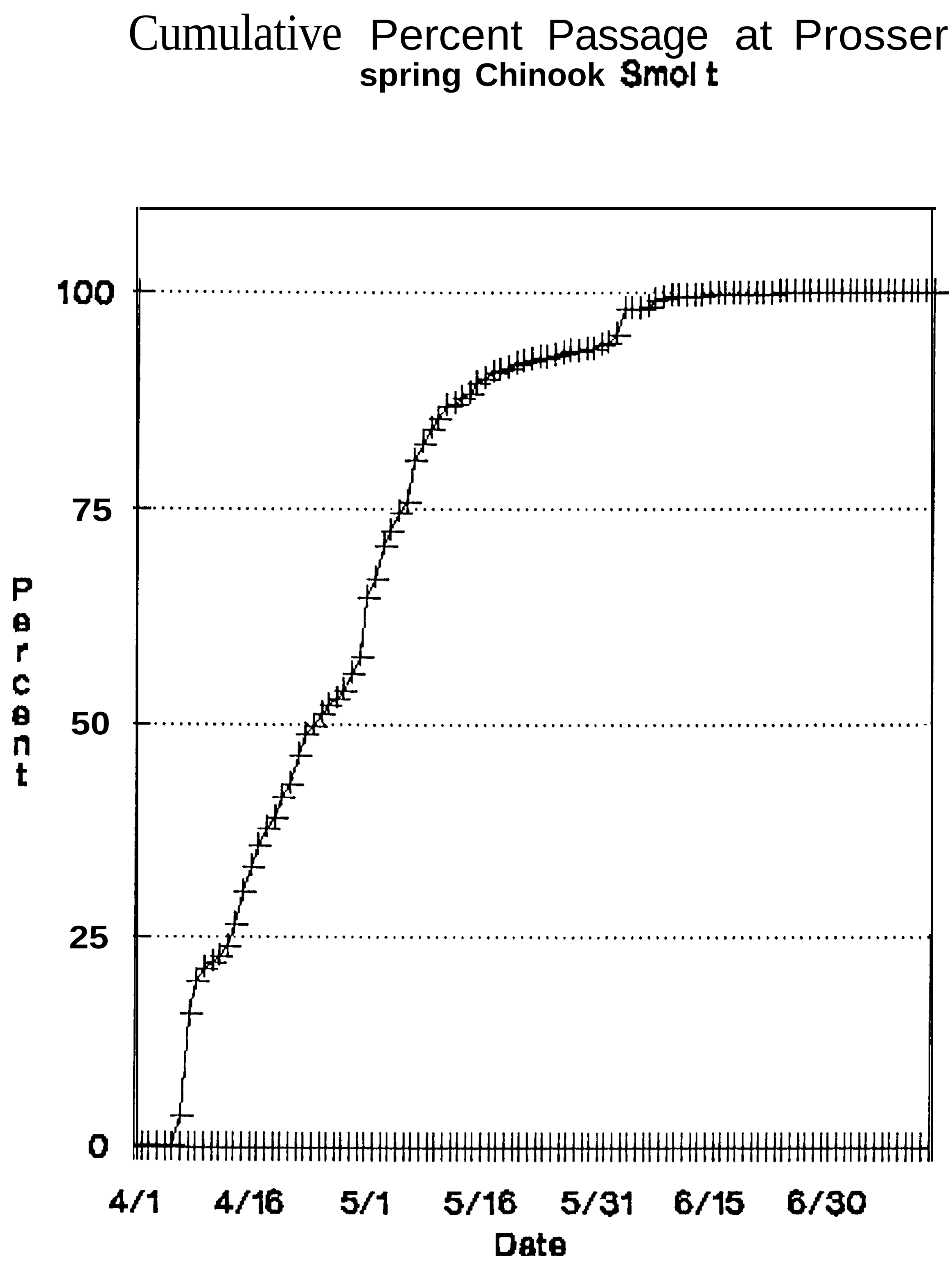

Figure 2. Cumulative percent passage of wild spring chinook smolts at Prosser April 1 through July 13, 1989.

6.1.1.3 Distinguishing Spring from Fall Chinook Smolts.

Length frequencies and scale analyses were used to differentiate spring and fall chinook outmigrants. Explicitly, the number of wild fall chinook migrating past Prosser Dam in a given week was estimated as follows:

$$N_j \sum_{i=a}^{i=b} [(L_{i,j} \mid (F_{i,j})] = N_{f,j} \qquad \text{equation 1.}$$

where a and b are length increment bounds, with "a" representing "less that 40 mm, ", "b" representing "greater than 199 mm", and with intervening 5 mm steps --(40-44,45-49,...,195-199);

$L_{i,j}$ = the percent of sampled wild chinook in week j falling in length interval i ;

$F_{i,j}$ = the percent of fish in length interval i in week j determined from scale analysis to be fall chinook, i.e., O-age;

N_{-j} = the estimated outmigration of all wild chinook in week j ; and

$N_{f,j}$ = the estimated number of wild fall chinook in week j.

6.1.2 WAPATOX SMOLT TRAP

The fall pre-smolt outmigration was only monitored during October because operation of Wapato Diversion Canal ceased in order to provide adequate instream flows downstream to the facility. The estimated number of spring chinook outmigrants in October was 7,820 (Table 4). Mean fork length in October was 90 mm.

The smolt outmigration was monitored March 4, when the screens were installed, through June 17. A monthly summary of the estimated number of spring chinook outmigrants in 1988 is presented in Table 4. Estimated spring chinook smolt outmigration in March, April, May and June was 11,076; 27,725; 1,295 and 269 respectively. Total estimated outmigration past Wapatox was 40,365 smolts.

The estimated weekly catch of spring chinook is presented in Table 5. Highest estimated outmigration occurred April l-7, when an estimated 13,282 smolts outmigrated. This represents 60.3% of the total estimated outmigration. Median passage date was April 5.

Monthly size distributions of spring chinook smolts are presented in Figure 3. Mean monthly fork lengths in April, May and June were 92, 95 and 96 mm, respectively.

Table 4. Summary of monthly outmigration of spring chinook at Wapatox for 1985 through 1989.

Year	Species	March	April	May	June	July	August	September	October	November
1985	Spring chinook	\a	38,786	2,823	323	193	140	4,941	39,271	15,573 \b
1986	Spring chinook	\a	2,925	3,902	765	509	169	2,178	8,707	48,779
1987	Spring chinook	\a	13,561	2,335	245	608	1,158	3,464	7,820	\a
1988	Spring chinook	11,076	27,725	1,295	269	\a	\a	1,391	11,596	13,439 \c
1989	Spring chinook	\a	18,435	723	193	\d	\d	\d	\d	\d

\a Trap. not in operation.

\b Trap was only operated November 1 to November 10.

\c Trap was only operated November 1 through November 23.

\d Data not available at time of writing.

Table 5. Estimated weekly and monthly catches of spring chinook at Wapatox for fall, 1988 and spring, 1989.

Date (week ending) (date)	Weekly count	Cummulative count
Fall, 1988		
08-Sep	116	116
15-Sep	311	427
22-Sep	597	1,024
29-Sep	317	1,341
06-Oct	175	1,516
13-Oct	749	2,265
20-Oct	2,644	4,909
27-Oct	4,581	9,490
03-Nov	6,519	16,009
10-Nov	8,947	24,956
17-Nov	972	25,928
24-Nov /a	490	26,418

	Sep.	Oct.	Nov. /b
Fall totals	1,391	11,596	13,439

Date (week ending) (date)	Weekly count	Cummulative count
Spring, 1989		
07-Apr	4,486	4,486
14-Apr	8,301	12,787
21-Apr	4,465	17,252
28-Apr	1,126	18,378
05-May	246	18,624
12-May	239	18,863
19-May	150	19,013
26-May	103	19,116
02-Jun	59	19,175
09-Jun	52	19,227
16-Jun	49	19,276
23-Jun	30	19,306
30-Jun	46	19,352

	April	May	June	Season
Spring totals	18,435	723	193	19,351

/a Was operated only six days this week.
/b November 23 was the last day of operation.

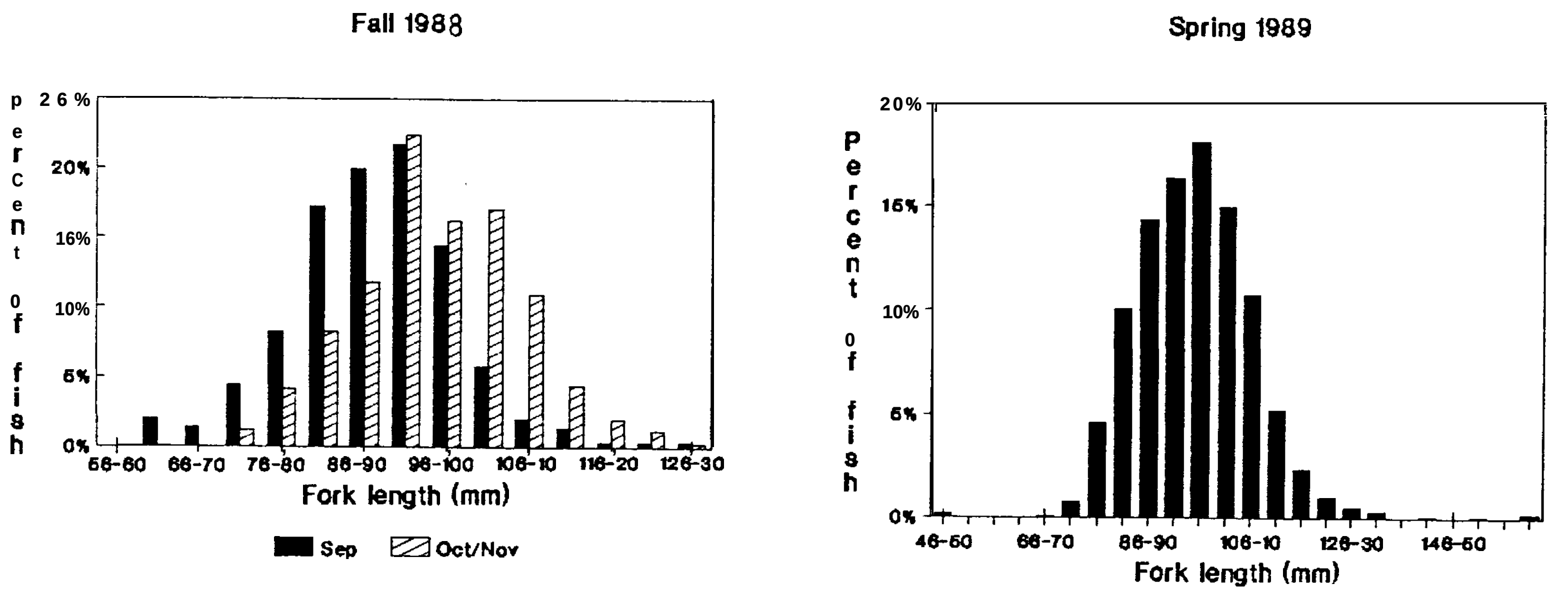

Figure 3. Monthly size distribution of spring chinook at Wapatox in October 1988 and March, April and May 1989.

6.1.3 ROZA SMOLT TRAP

Because the flow to entrainment relationship has yet to be established at the Roza smolttrap only a qualitative analysis of the data is possible. A catch summary is presented in Table 6. Total catches from April through August were 446 spring chinook smolts and 5,581 spring chinook young-of-the-year. Spring chinook smolts were captured from April 1 through May. The mean fork length for spring chinook smolts was 115 mm. Mean parr fork length was 83 mm in July and 89 mm in August. Spring chinook fry were first observed April 6, and outmigration continued throughout the summer. Both the mean fork length and date of capture indicated that newly emergent fry were moving past Roza Dam from the upper Yakima River. Past spring chinook egg-to-fry data collected in the upper Yakima River (1988 BPA Annual Report) indicates that the median date of emergence ranges from April 1 to May 17. In 1988, the lowest spring chinook redd upstream of Roza Dam was located at RM 140, over 12 miles away. Therefore fry must be moving a considerable distance shortly after emergence. The fact that young-of-the-year spring chinook were captured throughout the summer supports evidence collected from distribution studies in 1983-85 (Fast et.al., 1985) indicating a continuous migration of juvenile spring chinook from spawning areas into the Yakima Canyon.

Table 6. Temporal distribution of capatures of Spring Chinook juvenile at Roza Dam, April through August, 1989.

DATE	Spring chinook smolts	Spring chinook parr
01-Apr	25	0
02-Apr	8	0
03-Apr	7	0
04-Apr	9	0
05-Apr	2	0
06-Apr	61	197
07-Apr	31	325
08-Apr	18	379
09-Apr	23	1109
10-Apr	29	1032
11-Apr	23	497
12-Apr	8	200
13-Apr	15	119
20-Apr	3	43
21-Apr	10	83
22-Apr	2	58
25-Apr	28	190
26-Apr	17	97
27-Apr	37	114
05-May /a	19	0
18-May /b	11	116
25-May /c	22	25
01-June	38	7
15-June		60
22-June		429
29-June		120
06-Jul		202
13-Jul		30
20-Jul		18
27-Jul		36
03-Aug		10
04-Aug		44
10-Aug		15
17-Aug		16
24-Aug		8
31-Aug		2

/a Start time was 1100, the 5th, and end time was 1700 the 5th.
/b Start time was 1300 the 18th.
/c Start time was 1730 the 25th, and end time was 0945 the 26th.

6.1.4 ADULT RETURNS

In 1989 a total of 4,115 adult and 244 jack spring chinook salmon returning to the Yakima River were counted at Prosser fish ladder at RM 48 (Tables 7 and 8). This gives a total of 4,359 salmon returning to Prosser Dam (Table 9). This number may be underestimated due to a temporarily inefficient counting station on the new center ladder at Prosser Dam (as much as two feet of water passed above the viewing windows). The raw daily fish counts for Prosser Dam are presented in Appendix Tables A.1 through A.5. The mean dates of passage were May 15 and May 24 for adults and jacks respectively. An additional 560 fish were estimated to have been caught in the Yakima River subsistence dipnet fishery below Horn Rapids and Prosser Dams (Table 10). Therefore, total return to the Yakima system was 4,919 spring chinook salmon (Table 11).

Spring chinook were counted at Roza Dam from May 3 to September 29, 1989. Counts at Roza Dam were 3,561 adult and 211 jack spring chinook for a total of 3,772 (Tables 12., 13, and 14). A total of 236 hatchery spring chinook were collected at Roza Dam and sacrificed to recoverthe codedwiredtags for release group identification. An additional 187 fish were harvested between Prosser and Roza Dams in the subsistence dipnet fishery (Table 10). Daily counts of fish passage at Roza Dam are presented in Appendix Tables B.l through B.5.

Table 7. Weekly adult spring chinook passage at Prosser Dam, 1989. (1) Index week number; (2) Week-ending date; (3) Weekly passage; (4) Weekly proportion; (5) Cumulative passage; (6) Cumulative proportion

(1)	(2)	(3)	(4)	(5)	(6)
15	415	0	0.0000	0	0.0000
16	422	3	0.0007	3	0.0007
17	429	153	0.0372	156	0.0379
18	506	570	0.1385	726	0.1764
19	513	901	0.2190	1627	0.3954
20	520	1283	0.3118	2910	0.7072
21	527	693	0.1684	3603	0.8756
22	603	310	0.0753	3913	0.9509
23	610	58	0.0141	3971	0.9650
24	617	71	0.0173	4042	0.9823
25	624	44	0.0107	4086	0.9930
26	701	a	0.0019	4094	0.9949
27	708	15	0.0036	4109	0.9985
28	715	2	0.0005	4111	0.9990
29	722	2	0.0005	4113	0.9995
30	729	0	0.0000	4113	0.9995
31	805	2	0.0005	4115	1.0000

Median date: May 15

Table a. Weekly jack spring chinook passage at Prosser Dam, 1989. (1) Index week number; (2) Week-ending date; (3) Weekly passage; (4) Weekly proportion; (5) Cumulative passage; (6) Cumulative proportion

(1)	(2)	(3)	(4)	(5)	(6)
15	415	0	0.0000	0	0.0000
16	422	0	0.0000	0	0.0000
17	429	3	0.0123	3	0.0123
18	506	9	0.0369	12	0.0492
19	513	21	0.0861	33	0.1352
20	520	44	0.1803	77	0.3156
21	527	87	0.3566	164	0.6721
22	603	46	0.1885	210	0.8607
23	610	11	0.0451	221	0.9057
24	617	10	0.0410	231	0.9467
25	624	5	0.0205	236	0.9672
26	701	2	0.0082	238	0.9754
27	708	4	0.0164	242	0.9918
28	715	2	0.0082	244	1.0000

Median date: May 24

Table 9. Weekly total spring chinook passage at Prosser Dam, 1989. (1) Index week number; (2) Week-ending date; (3) Weekly passage; (4) Weekly proportion; (5) Cumulative passage; (6) Cumulative proportion

(1)	(2)	(3)	(4)	(5)	(6)
13	401	0	0.0000	0	0.0000
14	408	0	0.0000	0	0.0000
15	415	0	0.0000	0	0.0000
16	422	3	0.0007	3	0.0007
17	429	I.56	0.0358	159	0.0365
la	506	579	0.1328	738	0.1693
19	513	922	0.2115	1660	0.3808
20	520	1327	0.3044	2987	0.6852
21	527	780	0.1789	3767	0.8642
22	603	356	0.0817	4123	0.9459
23	610	69	0.0158	4192	0.9617
24	617	81	0.0186	4273	0.9803
25	624	49	0.0112	4322	0.9915
26	701	lo	0.0023	4332	0.9938
27	708	19	0.0044	4351	0.9932
28	715	4	0.0009	4355	0.9991
29	722	2	0.0005	4357	0.9995
30	729	0	0.0000	4357	0.9995
31	805	2	0.0005	4359	1.0000

Median date: May 16

Table 10. YIN Yakima River spring chinook fishery, 1981 - 1989.

	Estimated chinook	Horn Rapids harvests		Prosser harvests		Sunnyside harvests		Uapato harvests		Total harvests	
Year	run size	CH	SH	CH	SH	CH	SH	CH	SH	CH	SH
1981	1,334	0	0	49	2	137	1	30	0	216	3
1982	1,686	10	0	78	0	241	11	105	2	434	13
1983	1,324	0	0	72	1	9	11	3	0	a4	16
1984	2,677	3	0	116	4	122	18	48	3	289	25
1985	4,529	54	0	267	3	61	0	483	21	865	24
1986	9,442	158	3	372	2	212	0	598	0	1,340	5
1987	4,390	40	0	332	0	60	0	114	6	546	6
1988	4,247	220	0	113	0	42	0	69	0	444	0
1989	4,920	560[a]	6[a]			187[b]	0[b]			747	6
81-88[c]											
Average	3,839	61	0	175	2	111	5	181	4	527	12

[a] Combined harvest at Horn Rapids and Prosser.

[b] Combined harvest at Sunnyside and Uapato.

[c] 1989 was not used in average due to combining reaches.

Table 11. Estimated spring chinook runs to the Yakima River basin, 1957-1989.

Year	Total redds[a] Naches	Yakima	Total	Escapement[b]	Harvest[c]	Total run
1957	764	1216	1980	4752	7913	12665
1958	284	531	815	1956	4401	6357
1959	306	255	561	1346	3464	4810
1960	126	184	310	744	3668	4412
1961	166	175	341	818	5044	5862
1962	153	76	229	550	4185	4735
1963	185	—	—	—	2992	—
1964	50	81	131	314	3241	3555
1965	53	90	143	343	1763	2106
1966	95	32	127	305	4800	5105
1967	58	97	155	388	3195	3583
1968	25	61	86	206	2430	2636
1969	50	309	359	862	618	1480
1970	48	23	71	170	1512	1682
1971	—	97	—	—	1232	—
1972	55	101	156	374	480	854
1973	28	41	69	166	3221	3387
1974	30	40	70	168	1748	1916
1975		104	—	—	600	—
1976	35	108	143	343	—	—
1977	10	121	131	314	—	—
1978	95	308	403	967	—	—
1979	153	86	239	574	—	—
1980	113	353	466	1118	106	1224
1981	172	294	466	1118	216	1334
1982	54	573	626	1252	434	1686
1983	83	360	443	1240	84	1324
1984	220	634	854	2050	289	2677[d]
1985	427	951	1378	3582	865	4527[d]
1986	1298	1780	3078	7387	1300	8687
1987	675	956	1631	3294	546	4390
1988	480	566	1046	3242	444	4247
1989	520	933	1453	4172	747	4919

[a]Redd counts for 1957-1961 are total redd counts from Major and Mighell (1969). For 1962-1980 the counts are index counts from WDF or YIN coordinated surveys. Index counts in this time period were expanded by 1.8 and 2.5 for the upper Yakima and Naches systems, respectively. (Expansion factors were derived from the ratio of index counts to total counts for the respective systems. Total counts were from the Major and Mighell study and from the 1981-1987 surveys.) For 1981-1987 the counts are total redd counts from USFWS, YIN, and WDF cooperative surveys.
[b]Based on Roza Dam counts the number of fish per redd has overaged 2.4 in the upper Yakima since 1982. Historical escapement for 1958 to 1981 was therefore estimated as the total redd count multiplied by 2.4. For 1982 to 1987 the actual number of fish per redd was used to expand the total redd count.
[c]1957-1975 WDF tribal harvest estimates; 1980-1987 YIN tribal harvest estimates. All harvest estimates are for the Yakima River only.
[d]Total run estimates since 1984 are the sum of the Prosser Dam counts and the estimated harvests below Prosser Dam.

Table 12. Weekly adult spring chinook passage at Roza Dam, 1989. (1) Index week number; (2) Week-ending date; (3) Weekly passage; (4) Weekly proportion; (5) Cumulative passage; (6) Cumulative proportion

(1)	(2)	(3)	(4)	(5)	(6)
18	506	24	0.0067	24	0.0067
19	513	36	0.0101	60	0.0169
20	520	426	0.1196	486	0.1365
21	527	766	0.2151	1252	0.3516
22	603	822	0.2308	2074	0.5824
23	610	481	0.1351	2555	0.7175
24	617	354	0.0994	2909	0.8169
25	624	135	0.0379	3044	0.8548
26	701	105	0.0295	3149	0.8843
27	708	48	0.0135	3197	0.8978
28	715	54	0.0152	3251	0.9129
29	722	58	0.0163	3309	0.9292
30	729	41	0.0115	3350	0.9407
31	805	55	0.0154	3405	0.9562
32	812	34	0.0095	3439	0.9657
33	819	18	0.0051	3459	0.9708
34	826	29	0.0081	3486	0.9789
35	902	16	0.0045	3502	0.9834
36	909	14	0.0039	3516	0.9874
37	916	13	0.0037	3529	0.9910
38	923	18	0.0051	3547	0.9961
39	930	14	0.0039	3561	1.0000

Median date: June 01

Table 13. Weekly jack spring chinook passage at Roza Dam, 1989. (1) Index week number; (2) Week-ending date; (3) Weekly passage; (4) Weekly proportion; (5) Cumulative passage; (6) Cumulative [redacted]

(1)	(2)	(3)	(4)	(5)	(6)
19	513	1	0.0047	1	0.0047
20	520	0	0.0000	0	0.0000
21	527	6	0.0284	7	0.0332
22	603	25	0.1185	32	0.1517
23	610	11	0.0521	43	0.2038
24	617	16	0.0758	59	0.2796
25	624	7	0.0332	66	0.3128
26	701	17	0.0806	83	0.3934
27	708	11	0.0521	94	0.4455
28	715	12	0.0569	106	0.5024
29	722	18	0.0853	124	0.5877
30	729	11	0.0521	135	0.6398
31	805	17	0.0806	152	0.7204
32	812	11	0.0521	163	0.7725
33	819	12	0.0569	175	0.8294
34	826	13	0.0616	188	0.8910
35	902	6	0.0284	194	0.9194
36	909	10	0.0474	204	0.9668
37	916	4	0.0190	208	0.9858
38	923	2	0.0095	210	0.9954
39	930	1	0.0047	211	1.0000

Median date: July 13

Table 14. Weekly total spring chinook passage at Roza Dam, 1989
(1) Index week number; (2) Week-ending date; (3) Weekly passage;)
(4) Weekly proportion; (5) Cumulative passage; (6) Cumulative proportion

(1)	(2)	(3)	(4)	(5)	(6)
18	506	24	0.0064	24	0.0064
19	513	37	0.0098	61	0.0162
20	520	426	0.1129	487	0.1291
21	527	772	0.2047	1259	0.3338
22	603	847	0.2245	2106	0.5583
23	610	492	0.1304	2598	0.6888
24	617	370	0.0981	2968	0.7869
25	624	142	0.0376	3110	0.8245
26	701	122	0.0323	3232	0.8568
27	708	59	0.0156	3291	0.8725
28	715	66	0.0175	3357	0.8900
29	722	76	0.0201	3433	0.9101
30	729	52	0.0138	3485	0.9239
31	805	72	0.0191	3557	0.9430
32	812	45	0.0119	3602	0.9549
33	819	30	0.0080	3632	0.9629
34	826	42	0.0111	3674	0.9740
35	902	22	0.0058	3696	0.9799
36	909	24	0.0064	3720	0.9862
37	916	17	0.0045	3737	0.9907
38	923	20	0.0053	3757	0.9960
39	930	15	0.0040	3772	1.0000

Median date: June 1

The median dates of passage at Roza Dam were June 1 and July 13 for spring chinook adults and jacks respectively.

Upper Yakima Surveys: A total of 937 redds were reported from surveys on the upper Yakima and its tributaries. The Cle Elum River total was 192, the highest count since surveys have been initiated. Nine redds were located above Easton Dam and a total of 707 were in the Yakima River between Easton and Roza Dams. An additional 29 redds were discovered in the area between Roza Dam and Selah Bridge.

Naches Surveys: There were a total of 520 redds found on the Naches River in 1989. This represents a slight increase from 1988.

Due to the probable fall-back of spring chinook at Roza Dam as discussed earlier, the total passage of 3,756 is probably over-estimated. Thus, no estimates of fish per redd have been presented. Hopefully, a tagging study can be arranged to determine to what extent fall-back is occurring in 1990.

6.1.5 ESTIMATES OF SURVIVAL THROUGH VARIOUS LIFE STAGES

6.1.5.1 Egg to Fry:

Survival from egg to fry was investigated in 1985 and 1986 by capping a number of redds in the upper Yakima with fine-meshed nets equipped with live-boxes on their downstream ends (see BPA Annual Reports for 1985 and 1986). An estimate of the number of eggs deposited in these redds was obtained by snagging (with hook and line) spent females off the redd, and substituting their length into the length-fecundity relationship. The fry were counted out of the live-boxes on a daily basis from early March through June. Survival from egg to emergent fry was estimated as the total number of fry removed divided by the estimated egg deposition. Mean survival was estimated as 62.5 percent in 1985 and 56.7 percent in 1986. The mean of these estimates, 59.6 percent, has been assumed to be characteristic of the system.

Estimates of total egg deposition in the Yakima Subbasin have been revised substantially in the wake of intensive scrutiny associated with the production of the Yakima Subbasin Plan (Watson, 1989). New estimates for subbasin egg deposition (Table 15) in the brood years 1981through 1987 were generated as follows. As before, total egg deposition was estimated as the sum of three distinct subareas--the upper Yakima River, the American River, and the Naches system exclusive of the American

River (Table 15). because of the differential age and size distributions of females spawning in each subarea. The age distribution of females spawning in a given subarea and year was estimated from the length (mid-eye hypural) distributions of recovered carcasses and an age/length relationship developed for fel ale Yakima River spring chinook. The latter relation ship was based on over 600 fish of known length (mid-eye hypural) collected from the subsistence fishery and froa spawning grounds which were aged by scale analysis. ‘his relationship assigned a probability of age to each small increment of length--e.g., (number age-IV 60-65 cm)/(total number fish 60-65 cm in dataset). Age-specific mean fecundities for a given subarea and year were then determined by substituting age-specific mean lengths into the length-fecundity relationship. Finally, the egg complement of the redds in a given subarea and year was assumed to reflect the age distribution of the spawners: viz., if x, y and z percent of the female spawners were three-, four-, and five-year-olds, then x, y, and z percent of the redds were assumed to contain the egg complement of the average three-, four- and five-year-old female for the subarea and year under consideration. Thus, total egg deposition was estimated as the product of age-specific fecundity and "age-specific r dd number" summed over all ages and subareas.

Table 15 -Egg deposition estimates for Yakima Basin spring chinook, 1981-1987.

Procedure: The egg complement of the redds attributed to each substock in a given year is assumed to reflect the age distribution of the spawners : if x, y and z percent of the females were threes, fours and fives, respectively, then x, y and z percent of the redds are assumed to contain the egg complement of the average three-, four- and five-year-old female for the suhstock and year at issue. The age-specific mean lengths for **females** of **all three substocks, as listed** in Table 1a6., are entered in the length-fecundity expression described in Table Ibl., the resulting numbers are multiplied by the appropriate number of redds, and the products are summed over all age classes.

BROOD YEAR	SUBSTOCK	AGE	FRACTION FEMALES AT AGE	MEAN LENGTH(a.)	AGE-SPECIFIC MEAN FECUNDITY	NUMBER OF REDDS	REDDS FROM FEMALES AT AGE	EGGS DEPOSITED SUBSTOCK	EGGS DEPOSITED BASIN
1981	AMERICAN	III	0	0	0	72	0	0	
(SMOLT	AMERICAN	IV	0.814	66.7	5286	72	58.608	309817	
YEAR	AMERICAN	V	0.186	71.4	6204	72	13.392	83083	
1983)									
	NACHES	III	0	0	0	100	0	0	
	NACHES	IV	0.888	62.8	4525	100	88.8	401802	
	NACHES	V	0.112	73.2	6555	100	11.2	73420	
	U. YAKIMA	III	0.034	48	1635	294	9.996	16345	
	U. YAKIMA	IV	0.955	57.6	3510	294	280.77	985364	
	U. YAKIMA	V	0.011	68.7	5677	294	3.234	18359	1888189
1982	AMERICAN	III	0	0	0	11	0	0	
(SMOLT	AMERICAN	IV	0.814	66.7	5286	11	a.954	47333	
YEAR	AMERICAN	V	0.136	71.4	6204	11	2.046	12693	
1984)									
	NACHES	III	0	0	0	43	0	0	
	NACHES	IV	0.888	62.8	4525	43	38.184	172775	
	NACHES	V	0.112	73.2	6555	43	4.816	31571	
	U. YAKIMA	III	0.034	48	1635	573	19.482	31855	
	U. YAKIMA	IV	0.955	57.6	3510	573	547.215	1920454	
	U. YAKIMA	V	0.011	68.7	5677	573	6.303	35781	2252462
1983	AMERICAN	III	0	0	0	36	0	0	
(SMOLT	AMERICAN	IV	0.814	66.7	5286	36	29.304	154909	
YEAR	AMERICAN	V	0.186	71.4	6204	36	6.696	41541	
1985)									
	NACHES	III	0	0	0	47	0	0	
	NACHES	IV	0.888	62.8	4525	47	41.736	188847	
	NACHES	V	0.112	73.2	6555	47	5.264	34507	
	U. YAKIMA	III	0.034	48	1635	360	12.24	20014	
	U. YAKIMA	IV	0.955	57.6	3510	360	343.8	1206568	
	U. YAKIMA	V	0.011	68.7	5677	360	3.96	22480	1668866

Table 15 Cont'. Egg deposition estimates for Yakima Basin spring chinook, 1981-1987.

BROOD YEAR	SUBSTOCK	AGE	FRACTION FEMALES AT AGE	MEAN LENGTH(a.)	AGE-SPECIFIC MEAN FECUNDITY	NUMBER OF REDDS	REDDS FROM FEMALES AT AGE	EGGS DEPOSITED SUBSTOCK	EGGS DEPOSITED BASIN
1984	AMERICAN	III	0	0	0	72	0	0	
(SMOLT	AMERICAN	IV	0.668	68.7	5677	72	48.096	273029	
YEAR	AMERICAN	V	0.332	76.1	7122	72	23.904	170235	
1986)									
	NACHES	III	0	0	0	148	0	0	
	NACHES	IV	0.896	58.8	3744	148	132.608	496458	
	NACHES	V	0.104	73.8	6673	148	15.392	102703	
	U. YAKIMA	III	0.04	44.3	913	634	25.36	23146	
	U. YAKIMA	IV	0.96	56	3197	634	608.64	1945888	
	U. YAKIHA	V	0	0	0	634	0	0	3011460
1985	AMERICAN	III	0	0	0	141	0	0	
(SMOLT	AMERICAN	IV	0.736	64.2	4798	141	103.776	497932	
YEAR	AHERICAN	V	0.264	75.5	7004	141	37.224	260733	
1987)									
	NACHES	III	0.1	46.8	1401	286	28.6	40064	
	NACHES	IV	0.714	64.7	4896	286	204.204	999735	
	NACHES	V	0.186	73.6	6633	286	53.196	352874	
	U. YAKIMA	III	0	0	0	951	0	0	
	U. YAKIMA	IV	0.977	60.5	4076	951	929.127	3786865	
	U. YAKIMA	V	0.023	72.9	6497	951	21.873	142104	6080308
1986	AMERICAN	III	0	0	0	464	0	0	
(SMOLT	AMERICAN	IV	0.422	70.9	6106	464	195.808	1195663	
YEAR	AMERICAN	V	0.578	77.6	7414	464	268.192	1988500	
1988)									
	NACHES	III	0	0	0	849	0	0	
	NICHES	IV	0.626	66.6	5267	a49	531.474	2799134	
	NACHES	V	0.374	76.6	7219	a49	317.526	2292289	
	U. YAKIMA	III	0.012	44.3	913	1774	21.288	19430	
	U. YAKIMA	IV	0.97s	59	3783	1774	1729.65	6543010	
	U. YAKIMA	V	0.013	72.9	6497	1774	23.062	149829	14987855
1987	AMERICAN	III	0	0	0	222	0	0	
(SMOLT	AMERICAN	IV	0.454	62.8	4525	222	100.788	456045	
YEAR	AMERICAN	V	0.545	78.4	7571	222	120.99	915975	
1989)									
	NACHES	III	0	0	0	455	0	0	
	NACHES	IV	0.574	66.9	5325	455	261.17	1390812	
	NACHES	V	0.426	76.5	7200	455	193.83	1395516	
	U. YAKIMA	III	0	0	0	1063	0	0	
	U. YAKIMA	IV	0.921	60.8	4134	1063	979.023	4047573	
	U. YAKIMA	V	0.078	72.5	6419	1063	82.914	532200	8738121

a. The length-fecundity expression used is : 195.248(MEHP length) - 7736.78. Note that the lack of sex-specific data for the American and Naches substocks in the years 1980-83 necessitated the use of 1980-83 mean figures for age distribution and length.

Note that total egg deposition for the years 1988 and 1989 has not yet been estimated by the refined procedure described above. This is so because there has not yet been time to estimate age distributions from the length frequencies of carcasses recovered during spawner surveys. Until this analysis is completed, egg deposition will be determined by the procedure used in previous Annual Reports. The old procedure used the mean lengths of females in each subarea (as observed in the 1985 spawner survey) andthelength-fecundity relationship to estimate the mean fecundity for spawning females in the American River (6,198 eggs), the upper Yakima River (3,908 eggs) and the Naches system exclusive of the American (5,150 eggs). The product of redd number and mean fecundity summed over subareas gave egg deposition. Using this old procedure, provisional estimates of egg deposition for the years 1988 and 1989 are as follows:

BROOD YEAR	SUBAREA	NUMBER OF REDDS	EGGS/REDD	EGG DEPOSITION
1988	American	239	6,198	1,481,322
	Yakima	241 566	5,150	1,241,150
			3,908	2,211,928
			Total	4,934,400
1989	American	187	6,198	1,159,026
	Yakima	333 928	5,150	1,714,950
			3,908	3.626.624
			Total	6,500,600

The estimated number of fry produced from the egg deposition in the 1981through 1989 brood years is summarized in Table 16. Again, these figures are based on an estimated 59.6 percent egg to emergent fry survival rate.

Table 16. Estimated fry production from eggs deposited in the Yakima Basin from 1981 through 1989.

BROOD YEAR	TOTAL EGG DEPOSITION	% SURVIVAL	TOTAL FRY
1981	1,888,189	59.6	1,125,360
1982	2,252,462	59.6	1,342,467
1983	1,668,866	59.6	994,644
1984	3,011,460	59.6	1,794,830
1985	6,080,308	59.6	3,623,864
1986	14,987,855	59.6	8,932,762
1987	8,738,121	59.6	5,207,920
1988	4,934,400[a]	59.6	2,940,902
1989	6,500,600[a]	59.6	3,874,358

a. Provisional estimate.

6.1.5.2 Egg to Smolt:

Estimates of egg to smolt survival have also been revised and reinterpreted as a result of the intensive modeling exercises conducted during Subbasin Planning. A description of the nature of these revisions follows.

Although brood year egg deposition and smoltpassage at Prosser can both be estimated with some accuracy, a large degree of uncertainty is associated with estimating egg to smolt survival. The problem arises from the fact that a substantial number of smolts are lost before reaching Prosser Dam and the counting station. If egg to smolt survival is expressed in terms of the number of smolts surviving to Prosser, egg to smolt survival will be underestimated by a factor equal to the proportion of fish lost in moving from upstream "staging areas" to the counting station. This "pre-Prosser" survival rate has been termed the "smolt to smolt" survival rate: the survival rate of smolts from their migratory starting point in the upper watershed to a point far down in the watershed, often defined as the confluence with the Columbia. Smolt to smolt survival must be determined if egg to smolt survival is not to be confounded with the losses suffered by fish en route to Prosser. Moreover, smolt to smolt survival rates are important in their own right; as will be seen, they may be small enough to represent a very serious limiting factor on smolt production.

<u>Smolt to smolt survival</u>. Smolt to smolt survival has been estimated for both hatchery and wild fish. The survival of hatchery fish from release points ranging from 57 to 145 miles above Prosser has been poor since monitoring began in 1983. Over the past six years, the mean survival of hatchery spring chinook, steelhead, fall chinook and coho has been 30 percent, 25 percent, 27 percent and 48 percent, respectively.

Releases of marked wild spring chinook smolts trapped at Roza and Wapatox Dams in April of 1988 (see Appendix C., 1988 Annual Report) allowed the estimation of wild smolt to smolt survival rates through three major migratory reaches: from Wapatox Dam on the Naches to Sunnyside Dam on the Yakima; from Sunnyside Dam to Prosser Dam; and from Prosser Dam to the Columbia confluence. Eleven distinctively cold-branded groups of wild Naches system spring chinook were released immediately below Wapatox Dam, and twelve groups of upper Yakima smolts were released above Roza Dam (four groups) above Sunnyside Dam (four groups), and several hundred yards below Sunnyside Dam (four groups). The mean survival of the "above Roza," "above Sunnyside," and "below Sunnyside" groups to Prosser was 56, 61 and 54 percent, respectively (mean = 57 percent). As there was no significant difference among survival rates for upper Yakima smolts released at these locations, it was concluded that essentially all losses in the reaches investigated occurred between Sunnyside and Prosser Dams, and that the survival through this reach is on the order of 57 percent. The mean survival of Naches smolts from Wapatox to Prosser was 40 percent, and this value was assumed characteristic of the reach.

The Naches confluence is upstream of Sunnyside. Thus, the product of the survival from Wapatoxto Sunnyside and Sunnysideto Prosser (0.57) should be 0.40, and:

(Survival Wapatox to Sunnyside)(0.57) = 0.40, and

(Survival Wapatox to Sunnyside) = 0.40/0.57 = 0.70.

Finally, adjusting Wapatox releases for the extra 30 percent mortality incurred between Wapatox and Sunnyside, the mean survival of all release groups (Naches and upper Yaklima) to McNary Dam was 35 percent. Thus, the product of the survival from Sunnyside to Prosser (0.57) and Prosser to McNary is 0.35, and:

(0.57)(Survival Prosser to McNary) = 0.35, and

(Survival Prosser to McNary) = 0.35/0.57 = 0.61.

The relative survival in the Yakima from Prosser to the Columbia confluence, and in the Columbia from the Yakima confluence to McNary, is unknown. However, both of these reaches are of approximately the same length. If losses through these reaches are a function of distance, survival from Prosser to the confluence and from the confluence to McNary might be equivalent. In the absence of data, this assumption was made, and survival rates through both reaches were assumed to be approximately 80 percent--(0.8)(0.8) = 0.64 =-0.61). Thus, cumulative survival of wild spring chinook smolts from Roza Dam to the Columbia confluence is approximately (0.57)(0.8) or 46 percent, and cumulative survival from Wapatox to the Columbia is approximately (0.4)(0.8) or 32 percent.

The mean survival to Prosser of aclimated hatchery spring chinook smolts has been about 60 percent of the rate observed for wild smolts in 1988. (Stress-related mortalities are minimized by pond-acclimation: thus, the proper hatchery rates to compare with the wild smolts survival rates should involve acclimated releases.) In the absence of additional data, it has been assumed that cumulative in-basin survival of hatchery spring chinook smolts will be about 40 percent lower than the wild rate. It is speculated that this difference may be attributable to the failure of hatchery-reared fish to learn appropriate predator avoidance behavior (see below).

From 1984 to the present, an increa sing number of screens and smolt by-pass systems have been rebuilt, and by April of 1989, all major diversion on the mainstem Yakima were refitted with state-of-the-art screens. Nevertheless, smolt survival rates have remained low.

Continuing poor smolt survival might be mainly attributable to predation in reaches of the open river, particularly those reaches below major diversions. These reaches can be severely dewatered during dry springs. The predator under greatest suspicion is the northern squawfish, although gulls and herons are known to feed heavily on smolts in a few locations. The specific mechanism proposed is as follows. River flows, water velocities and mean depths in the middle and lower reaches of the river drop substantially during the course of the outmigration as temperatures rise and irrigation demand increases reduced velocityies extend migration tim, prolonging the period of vulnerability. In a dry spring, these drops are earlier an more pronounced. As the river shrinks and fewer near-shore refuges are accessible, smolts and predators are concentrated in smaller areas, and the consumption rates of predators increases (the functional response). Smolts at the end of the outmigration could be especially hard hit, as increasing water temperatures accelerate predator consumption rates.

The literature indicates smolt losses of the magnitude observed in the Yakima could be mainly or entirely caused by squawfish. In the last two weeks of April, 1987, when 57 percent of the spring chinook outmigration occurred, the passage at Prosser was estimated at 141,000 spring chinook smolts. Assuming 1/14th of this number entered the reach from Sunnyside Dam to Prosser Dam each day of these two weeks, the mean smolt density in the Sunnyside to Prosser reach would have been 1130 smolts per square kilometer. Vigg (1988) developed a functional response relationship for squawfish in the John Day Reservoir predicting predator consumption rates (smolts/predator/day) as a function of smolt density. This relationship suggested that squawfish in the Sunnyside to Prosser reach in the last two weeks of April, 1987, would have been consuming about 0.3 smolts per day. (Note that this figure is probably low, as the area of the reach used in the density calculation was based on bank-full flow. Flows in late April, 1987, were not bank-full, and density may have been twice as great as the figure used. A consumption rate of 0.3 smolts/squawfish/day may, however, be fairly descriptive of the mean rate over the entire outmigration period.) The total outmigration in the spring (March through June) of 1987 was 252,000. Assuming 57 percent of this figure was lost in the Sunnyside to Prosser reach, the total number entering the reach must have been 252,000/.57 or 442,000, and the number lost was therefore 190,000. If squawfish feed at a rate of 0.3 smolts/day/squawfish over a 68-day period (April through the first week of June), it would take 190,000/(68 X 0.3) or about 9,300 squawfish to consume 190,000 smolts. If the consumption rate were 1 smolt/day, the necessary population would be only 2,800 squawfish.

Squawfish populations as large as 9,300 could easily reside in the Yakima system. The total area of the mainstem Yakima and Naches drainage (at bank-full flows) is about 3,030 hectares. If squawfish densities in the Yakima are comparable to the la/hectare observed in Lake Washington (Bartoo, 1977), as many as 36,360 squawfish could reside in the drainage.

Egg to smolt survival. Egg to smolt survival for brood years 1981through 1987 are summarized in Table 18. Note that egg deposition estimates have been revised as previously discussed, and annual outmigrationtotals have been limited to "spring migrants," defined as smolts passing Prosser between March land June 30. In addition, an effort was made to make outmigration totals temporally comparable--viz., to make each year's total reflect a migration period of exactly March 1 through June 30. This effort entailed the extrapolation of catch rates "backward in time,ti to account for late starting dates, as well as the occasional use of mean catch rates observed at the beginning and end of periods of downtime to estimate passage when the trap was temporarily out of operation. Because of these revisions, the outmigration figures for earlier brood years (1981-1986) presented in Table 17 will differ from figures published in earlier Annual Reports.

Note that egg to smolt survival ($S_{e/s}$) is expressed in two ways in Table 17. The egg to smolt survival rate expressed in terms of "smolts at Prosser" was calculated by dividing the number of spring outmigrants counted at Prosser by egg deposition; consequently, this figure reflects upstream smolt losses. This is the type of $S_{e/s}$ reported for the Yakima River by Major and Mighell (1969). The rate expressed in terms of "headwater smolts" estimates $S_{e/s}$ as if survival from headwater rearing areas to Prosser were 100 percent. In the latter calculation, it was assumed that dividing the

Table 17. Egg to smolt survival ($S_{e/s}$) for brood years 1981 through 1987 (smolt runs of 1983 through 1989) in the Yakima Basin (Note that only smolts passing Prosser in the period March 1 through June 30 are counted).

BROOD YEAR	EGG DEPOSITION	PROSSER SMOLTS	HEADWATER SMOLTS	$S_{e/s}$ AT PROSSER (percent)	$S_{e/s}$ AT HEADWATERS (percent)
1981	1,888,189	165,145	342,624	8.7	18.1
1982	2,252,462	143,327	297,359	6.4	13.2
1983	1,668,866	96,333	199,861	5.8	12.0
1984	3,011,460	180,789	375,081	6.0	12.4
1985	6,080,308	251,975	522,770	4.1	8.6
1986	14,987,855	282,409	587,085	1.9	3.9
1987	8,738,121	92,928	192,797	1.1	2.2

outmigration as observed at Prosserby the mean, basin-wide survival rate (to Prosser) would correct for losses in transit. Weighted by relative smolt capacity in the Naches and upper Yakima drainages, this basin-wide survival rate is approximately 48 percent. (Note that these "egg to headwater smolt" survival rates are intended only asroughapproximations. Layingasidetheissueofthea ccuracy and completeness of the "headwater to Prosser" survival rates estimated for the 1988 outmigration, it is certain that in-basin survival rates will vary between years.)

Note that the number of winter migrants (pre-smolts passing Prosser in the winter preceding their second spring) produced by the brood years 1985, 1986 and 1987 represented, respectively, 23.7, 20.0 and 15.2 percent (mean = 19.7 percent) of total brood year outmigration. If winter migrants are considered functionally equivalent to typical spring smolts, and if ~20 percent of every outmigration consists of winter migrants, thenbothtypesofeggto smolt survival rates should be increased by 20 percent.

It is instructive to compare the egg to smolt survival rates estimated in recent years with the estimates Major and Mighell (1969) made in the early 1960s. In1987 Dick Major graciously supplied the YIN Fisheries staff with the raw data upon which egg to smolt survival rates were estimated for the brood years 1957-1961 (smolt outmigrations of 1959-1963). YIN staff re-analyzed this data, and estimated egg deposition and spring smolt production by the same procedures employed in recent years. The results of this analysis are summarized in Table 18, which is directly comparable to Table 17.

Table 18. Egg to smolt survival ($S_{e/s}$) for brood years 1957 through 1961 (smolt runs of 1959 through 1963) in the Yakima Basin (Note that only smolts passing Prosser in the period March 1 through June 30 are counted).

BROOD YEAR	EGG DEPOSITION	PROSSER SMOLTS	HEADWATER SMOLTS	$S_{e/s}$ AT PROSSER (percent)	$S_{e/s}$ AT HEADWATERS (percent)
1957	12,052,000	467,196	969,286	3.9	8.0
1958	4,586,000	259,552	538,490	5.6	11.7
1959	3,351,000	214,895	445,840	6.4	13.3
1960	1,483,000	104,304	216,398	7.0	14.6
1961	2,653,000	273,388	567,195	10.3	21.4

The most significant feature of the figures in Table 17 is the pronounced downward trend in survival, especially over the last four outmigrations. It is also significant that egg to smolt survival appears to have declined in the past 25 years: expressed in terms of smolts at Prosser, the mean $S_{e/s}$ for brood years 1957-61 was 6.66 percent, whereas the mean for the brood years 1981-1987 is 27 percent lower, at 4.85 percent.

The estimates of egg to headwater smolts survival rates for both areas appear reasonable. The inverse releationship between egg deposition and survival indicates density dependence, and the survival rates associated with lower egg complements approach or exceed 20 percent, approaching the theoretical estimate of zero density egg to smolt survival (26 percent) derived by the Power Council's Modeling and Evaluation Group. It should be noted that the mean egg to smolt survival rate in the 1980s, expressed in terms of headwater smolts, compares favorably with the survival rates Bjornn (1978) estimated for spring chinook on the Lemhi River in Idaho. His estimates ranged from 4.0 to 15.9 percent, with a mean of 9.8 percent; the Yakima figures range from 2.2 to 18.5 percent, with a mean of 10.1 percent. The significance of this similarity might be that the Lemhi River above Bjornn's counting facility typically provides a much safer migration corridor than the Yakima.

There are at least two possible explanations for a higher egg to smolt survival rate in the early 1960s than in the 1980s. The first is that, for critical reaches and at critical times, river flows were generally higher

25 years ago. The second, and more serious possibiity is that, under existing flow conditions, the system may be approaching its juvenile carrying capacity.

Smolt losses in the reach between Sunnyside Dam and Prosser Dam can be expected to be inversely related to river flow during outmigration, especially if the predatory mechanism proposed in the previous section is valid. As can be seen in Table 19, river flows at Prosser Dam and below Sunnyside Dam averaged 5,447 cfs during April and May in the early 196Os, but only 3,861 cfs in the 1980s. Similarly, April-May flows below Sunnyside Dam averaged 3,459 cfs in the early 196Os, and 2,442 cfs in the 1980s. Moreover, winter flows in the main rearing and overwintering area, the Yakima Canyon, were higher in the 1960s than the 1980s. Lower winter flows in the Canyon reduce the accessibility of near-shore overwintering habitat (e.g., riprapped banks, root wads and other large organic debris), force more fish to weather the winter unprotected, and thus probably reduce overwinter survival. The mean overwinter flow in the Canyon in the 1980s (1,047 cfs) is 45 percent lower than the mean flowinthe 1960s (1,900 cfs). For the outmigrations of 1985 through 1988, mean winter flows in the Canyon were 772 cfs, 59 percent lower than the mean of the 1960s.

However important the changes in the hydrograph over the past 25 years may be, another concern is almost certainly more important: whether or not the existing system is approaching carrying capacity. A detailed computer simulation of spring chinook production in the Yakima system was an integral part of the Yakima Subbasin Plan (Watson, 1989). After the model was calibrated to existing run sizes, it was used to estimate maximum sustained yield to the terminal (i.e, Yakima River) fishery. The simulation of the existing system predicted the MSY runsize (into the Yakima) would be 4,910 fish, that the MSY exploitation rate w Id be 29 percent (producing a catch of .29(4,719) or 1,368 fish), and that the MSY spawning escapement would be 2,680. These figures are not too dissimilar from the existing condition. Since 1987, returns to the Yakima have been 4,390, 4,247 and 4,920 (mean=4,519), respectively. Over the same three years, terminal harvests have been 546, 444 and 747 (mean=579, terminal harvest rate has been 12, 10 and 15 percent (mean=12.3 percent), and spawning escapement has been 3,294, 3,242 and 4,173 (mean=3,570). Thus, although runsizes are similar to MSY levels, terminal exploitation has been lower and spawning escapement has been larger. In an att empt to predict the equilibrium condition of the existing "population exploited at current rates, the model was run for 100 years with a terminal exploitation rate of 1 .5 percent

When this was done, the population reached equilibrium at a runsize of 8,003 fish, with a terminal catch of 1,000 fish and a spawning escapement of 7,003. Thus, relative to the predicted equilibrium fishery, the system is currently producing at 4519/8003 or 56.6 percent of maximum.

It is unclear whether a population producing at 56 percent of capacity "should" display egg to smolt survival rates as low as those observed in the past two years. If declining egg to smolt survival rates are solely the result of density dependent processes, one would expect evidence of competition in the smolts monitored at Prosser. In particular, one would expect to see a decline in condition factor. If, on the other hand, declining survival rates have little to do with intraspecific competition, little change in condition factor would be expected. This issue will be pursued in the next Annual Report, and will be investigated in depth in the Completion Report.

Table 19. Mean April-May flows on the Yakima River at two sites of known smolt loss (Prosser Dam and the reach below Sunnyside Dam), and mean winter flows (October-February) in the major spring chinook overwintering area (Yakima Canyon). (Note that flows are specific to the year of outmigration: e.g., for the 1959 outmigration, flows were averaged at Prosser and Sunnyside Dam for April and May of 1959, and in the Yakima Canyon for October, 1958, through February, 1959.)

MEAN FLOWS A T - E R APRIL-MAY (cfs)		MEAN FLOWS BELOW SUNNYSIDE DAM APRIL-MAY (cfs)		MEAN FLOWS YAKIMA CANYON OCTOBER-FEBRUARY PRECEDING SPRING OF OUTMIGRATION (cfs)	
'59=5497	'83=6538	'59=3493	'83=4778	'59=2226	'83=1468
'60=5169	'84=3973	'60=3352	'84=2561	'60=3119	'84=1742
'61=8082	'85=3179	'61=5903	'85=2021	'61=1271	'85=892
'62=3963	'86=2911	'62=1964	'86=1291	'62=1328	'86=924
'63=4523	'87=3342	'63=2583	'87=1756	'63=1557	'87=687
	'88=2545		'88=1423		'88=586
	'89=4541		'89=3261		'89=1032
AVG 5447	3861	3459	2442	1900	1047

6.1.6.4 Smolt to Adult:

The smoltto adult (S_{sa}) survival based on the 1983 smolt outmigration estimated at Prosser and the 1984 return of jacks (3 year old fish), the 1985 return of four year old adults, and the 1986 return of five year old adults to the Yakima River is reported in Table 20. It was estimated that 6,012 wild three, four, and five year old fish returned from an estimated smolt outmigration of 135,548 fish in 1983.

The smelt t0 adult (S_{sa}) based on the 1984 smolt outmigration estimatedat Prosser and the 1985 return of jacks, the 1986 return of four year old adults and the 1987 return of five year old adults to the Yakima River is reported inTable 21.

The smelt t0 adult (S_{sa}) based on the 1985 smolt c&migration estimatedat Prosser and the 1986 return of jacks, the 1987 return of four year old adults, and the 1988 return of five year old adults to the Yakima River is report&i inTable 22.

The smolt to adult (Ssa) based on the 1986 smolt outmigration estimated at Prosser and the 1987 return of jacks, the 1988 return of four year old fish, and the 1989 return of five year old adults to the Yakima River is reported inTable23.

The smolt t0 adult (Ssa) based on the 1987 smolt outmigration estimated at Prosser and the 1988 return of jacks and the 1989 return of four year old adults to the Yakima River is reported in Table 24.

Table 20. Estimation of smolt to adult survival of the 1983 smolt outmigration from the Yakima system.

Adult (4 year old) returns	
Total adult return (4's + 5's) to Prosser	3,783
plus adult harvest below Prosser	321
Total return of adult (4's + 5's) to system	4,104
Adults to Roza [a]	2,125
plus 237 (spawning below Roza) [b]	237
plus 361 (harvest above Prosser) [c]	361
Total adults to Yakima [d]	2,723
Adults to Naches [e]	1,198
plus 183 (harvest above Prosser) [f]	183
Total adults to Naches	1,381
times 50% (4 year old fish) [g]	691
Total four year old returns to system	3,414
plus jacks that returned in 1984	248
plus five year old returns in 1986 [h]	2,440
Total 3, 4, and 5 year old returns	6,102
minus hatchery fish	90
Total wild 3, 4, and 5 year old returns	6,012
Wild smolts outmigrating in 1983	135,548
Survival $(S_{sa}) = \frac{6,102}{335,548} =$	4.4%

[a] Total adults counted at Roza fish ladder.

[b] Spring chinook calculated to spawn in Yakima River below Roza dam from 91 redds at 2.6 fish/redd = 237 fish.

[c] Estimate of percentage of 544 spring chinook that were harvested above Prosser and below Roza that would have gone up Yakima. Based on 66.3% of adult run returning to the Yakima and 33.7% to Naches.

[d] Estimated that 100% of the adults in the Yakima are four year old fish.

[e] Estimated as total return of adults to system minus adult count at Roza minus spawning below Roza minus harvest between Prosser and Roza.

[f] Estimate of percentage of 544 fish harvested above Prosser and below Roza that would have returned to the Naches system (33.7%).

[g] Estimated that 50% of the adults in the Naches system are four year old fish.

[h] From Table 22.

Table 21. Estimation of smolt to adult survival of the 1984 smolt outmigration from the Yakima system.

Adult (4 year old) returns	
Total adult return (4's + 5's) to Prosser	8,563
plus adult harvest below Prosser	530
Total return of adult (4's + 5's) to system	9,093
Adults to Roza [a]	2,967
plus 706 (spawning below Roza) [b]	706
plus 504 (harvest above Prosser) [c]	540
Total adults to Yakima [d]	4,213
Adults to Naches [e]	4,610
plus 270 (harvest above Prosser) [f]	270
Total adults to Naches	4,880
times 50% (4 year old fish) [g]	2,440
Total four year old returns to system	5,163
plus jacks that returned in 1985	423
plus five year old returns in 1987 [h]	1,010
Total 3,4, and 5 year old returns	6,596
minus hatchery fish	30
Total wild 3, 4, and 5 year old returns	6,566
Wild Smolts outmigrating in 1984	123,732
Survival $(S_{sa}) = \frac{6,519}{123,732} =$	5.3%

[a] Total adults counted at Roza fish ladder.

[b] Spring chinook calculated to spawn in Yakima River below Roza dam from 321 redds at 2.2 fish/redd = 706 fish.

[c] Estimate of percentage of 544 spring chinook that were harvested above Prosser and below Roza that would have gone up Yakima. Based on 66.7% of adult run returning to the Yakima and 33.3% to Naches.

[d] Estimated that 100% of the adults in the Yakima are four year old fish.

[e] Estimated as total return of adults to system minus adult count at Roza minus spawning below Roza minus harvest between Prosser and Roza.

Estimate of percentage of 810 fish harvested above Prosser and below Roza that would have returned to the, Naches system (33.3%).

[g] Estimated that 50% of the adults in the Naches system are four year old fish.

[h] From Table 23.

Table 22. Estimation of smolt to adult survival of the 1985 smolt outmigration from the Yakima system.

Adult (4 year old) returns	
Total adult return (4's + 5's) to Prosser	3,683
plus adult harvest below Prosser	222
Total return of adult (4's + 5's) to system	3,905
Adults to Roza [a]	1,610
plus 253 (spawning below Roza) [b]	253
plus 115 (harvest above Prosser) [c]	115
Total adults to Yakima [d]	1,978
Adults to Naches [e]	1,868
plus 183 (harvest above Prosser) [f]	57
Total adults to Naches	1,925
times 50% (4 year old fish) [g]	963
Total four year old returns to system	2,941
plus jacks that returned in 1986	349
plus five year old returns in 1988[h]	1,010
Total 3, 4 and 5 year old returns	4,300
minus hatchery fish	245
Total wild 3, 4, and 5 year old returns	4,055
Wild smolts outmigrating in 1985	
Survival $(S_{sa}) = \frac{4,055}{83,614} =$	4.9%

[a] Total adults counted at Roza fish ladder.

[b] Spring chinook calculated to spawn in Yakima River below Roza dam from 125 redds at 2.02 fish/redd = 253 fish.

[c] Estimate of percentage of 174 spring chinook that were harvested above Prosser and below Roza that would have gone up Yakima. Based on 66.3% of adult run returning to the Yakima and 33.7% to Naches.

[d] Estimated that 100% of the adults in the Yakima are four year old fish.

[e] Estimated as total return of adults to system minus adult count at Roza minus spawning below Roza minus harvest between Prosser and Roza.

[f] Estimate of percentage of 544 fish harvested above Prosser and below Roza that would have returned to the Naches system (33.7%).

[g] Estimated that 50% of the adults in the Naches system are four year old fish.

[h] from Table 24.

Table 23. Estimation of smolt to adult survival of the 1986 smolt outmigration from the Yakima system.

Adult (4 year old) returns	
Total adult return (4's + 5's) to Prosser	3,590
plus adult harvest below Prosser	333
Total return of adult (4's + 5's) to system	3,923
Adults to Roza [a]	1,633
plus 46 (spawning below Roza) [b]	46
plus 73 (harvest above Prosser) [c]	73
Total adults to Yakima [d]	1,752
Adults to Naches [e]	2,133
plus 38 (harvest above Prosser) [f]	38
Total adults to Naches	2,171
times 50% (4 year old fish) [g]	1,086
Total four year old returns to system	2,838
plus jacks that returned in 1987	335
plus five year old returns in 1989	1,086
Total 3,4 and 5 year old returns	4,259
minus hatchery fish	196
Total wild 3, 4, and 5 year old returns	4,063
Wild smolts outmigrating in 1986	169,077
Survival $(S_{sa}) = \frac{4,063}{169,077} =$	2.4%

[a] Total adults counted at Roza fish ladder.

[b] Spring chinook calculated to spawn in Yakima River below Roza dam from 19 redds at 2.04 fish/redd = 46 fish.

[c] Estimate of percentage of 111 spring chinook that were harvested above Prosser and below Roza that would have gone up Yakima. Based on 66.3% of adult run returning to the Yakima and 33.7% to Naches.

[d] Estimated that 100% of the adults in the Yakima are four year old fish.

[e] Estimated as total return of adults to system minus adult count at Roza minus spawning below Roza minus harvest between Prosser and Roza.

[f] Estimate of percentage of 111 fish harvested above Prosser and below Roza that would have returned to the Naches system (33.7%).

[g] Estimated that 50% of the adults in the Naches system are four year old fish.

Table 24. Estimation of smolt to adult survival of the 1987 smolt outmigration from the Yakima system.

Adult (4 year old) returns	
Total adult return (4's + 5's) to Prosser	4,115
plus adult harvest below Prosser	560
Total return of adult (4's + 5's) to system	4,675
Adults to Roza [a]	3,548
plus 59 (spawning below Roza) [b]	59
plus 124 (harvest above Prosser) [c]	124
Total adults to Yakima [d]	3,731
Adults to Naches [e]	881
plus 62 (harvest above Prosser) [f]	62
Total adults to Naches	943
times 50% (4 year old fish) [g]	472
Total four year old returns to system	4,203
plus jacks that returned in 1988	324
Total 3 and 4 year old returns	4,527
minus hatchery fish	179
Total wild 3 and 4 year old returns	4,348
Wild smolts outmigrating in 1987	251,975
Survival $(S_{sa}) = \frac{4,348}{251,975}$ =	1.7%

[a] Total adults counted at Roza fish ladder. NOTE-RECENT STUDY AT ROZA DAM INDICATED THAT THER WERE MANY FISH THAT MIGRATED THROUGH ROZA DAM AND THEN FELL BACK DOWN. THIS COULD CONFOUND THESE REPORTED NUMBERS.

[b] Spring chinook calculated to spawn in Yakima River below Roza dam from 29 redds at 2.04 fish/redd = 46 fish.

[c] Estimate of percentage of 187 spring chinook that were harvested above Prosser and below Roza that would have gone up Yakima. Based on 66.3% of adult run returning to the Yakima and 33.7% to Naches.

[d] Estimated that 100% of the adults in the Yakima are four year old fish.

[e] Estimated as total return of adults to system minus adult count at Roza minus spawning below Roza minus harvest between Prosser and Roza.

[f] Estimate of percentage of 187 fish harvested above Prosser and below Roza that would have returned to the Naches system (33.7%).

[g] Estimated that 50% of the adults in the Naches system are four year old fish.

6.2 HATCHERY OPERATIONS

6.2.1 OUTPLANTING STUDIES

6.2.1.1 Smolt releases

Three groups of spring chinook smolts were released from Mary's pond at RM 192 on the Yakima River and a fourth group was transported from Leavenworth National Fish Hatchery and scatter-planted directly into the upper Yakima River between RM 155 and 200 in 1986 and 1987, to evaluate the effectiveness of rearing and releasing hybrids and acclimating fish in earthen ponds and then allowing for a volitional release as smolts.

Similar releases were made from Nile Springs pond and the upper Yakima River in 1983 and 1984 and from Mary's pond and the upper Yakima River in 1985 to compare acclimation ponds vs. direct river releases. The 1986 release groups represented the first time the wild x wild and wild x hatchery hybrids were released. The 1987 release groups were a repetition of the 1986 releases. The 1983 release groups returned as six year old adults in 1987 and the 1984 release groups returned as four year old adults in 1986 and five year old adults in 1987. The 1985 release groups returned as four year old fish in 1987 and five year old fish in 1988. The 1986 release groups returned as four year old adults in 1988. Other release strategies tested were June fry plants and September and November parr releases in 1984 and 1985. Their survival rates will be discussed in the Hatchery Adult Return section of this report.

6.2.2 BROOD STOCK EVALUATIONS

An experimental brood stock program was undertaken in 1984 and continued in1985 to evaluate the effectiveness of using spring chinook adults from the Yakima River as a source of gametes for hatchery reared fish in an attempt to maintain the genetic components indigenous to the Yakima Basin. Crosses were made to obtain four different release groups; wil nales and wild females, wild males and hatchery female: and two groups of hatchery males and females. The firs t three groups were released in acclimation ponds and ie fourth group was released directly into the Yakima , er and compared with survival of group three - a cor tinuation of the acclimation pond vs. river release study. The required crosses were made in 1984 and 1985 from Yakima River brood stock adults taken from the Roza adult trap. The hybrids were reared at Leavenworth National Fish Hatchery and released as smolts. The first releases, the 1984 brood year products, were made from Mary's pond and the upper Yakima in 1986. The resulting progeny of the 1985 crosses were released at the same locations in 1987. Survival of each release group was calculated at Prosser smolt trap for smolt survival. The survival to returning adults will be determined for each group through 1990 when the five year old adults from the 1987 smolt releases return to the river.

6.2.3 ADULT HATCHERY RETURNS

Spring chinook adults from ten different hatchery release groups were recovered in 1989. These fish were identified by the coded wire tags recovered from the adult trap at Roza Dam, the Yakima River ceremonial dipnet fishery, and from spawning ground surveys and carcass recovery surveys conducted on the Yakima and Naches River systems in August, September and October of 1989. All fish passing Roza Dam were inspected for adipose clips and were sacrificed if clipped, to increase the recovery of coded wire tags. Table 25 presents the release data for all hatchery groups that could possibly return to the Yakima system as three, four, five or six-year-old fish in 1989 (one six year old adult was found in 1989). The 1989 tag recoveries were from a 1985 upper Yakima release group; the 1986 upper Yakima groups; the 1986 pre-smolt release groups and the 1986 and 1987 Mary's pond release groups. The expanded recoveries for each of the release groups is presented in Table 26. The adult returns from experimental releases will be analized after the five (5) year old returns or 1990.

Table 25. Tag data on all hatchery release groups that could have returned to the Yakima system in 1988.

Brood year	Tag code	Total number released	Release site	Number tagged	Mark rate (%)
1981	5-13-38	99,725	Nile Springs	94,529	94.8
1981	5-13-39	97,725	Upper Yakima	94,198	97.1
1982	5-11-47	29,636	Nile Springs	28,450	96.0
1982	5-11-48	45,552	Upper Yakima	41,573	97.7
1983	5-15-33	45,195	Marys Pond	43,297	95.8
1983	5-15-32	42,210	Upper Yakima(April)	40,436	95.8
1983	5-15-28	102,837	Upper Yakima(June)	93,064	90.5
1983	5-15-29	102,833	Upper Yakima(Sept.)	93,064	90.5
1983	5-15-30	108,305	Upper Yakima(Nov.)	102,229	94.4
1983	5-12-23	25,794	Rattlesnake	40,434	87.0
1984	5-15-45	100,750	Upper Yakima(June)	96,216	95.5
1984	5-15-46	101,724	Upper Yakima(Sept.)	95,621	94.0
1984	5-15-47	101,522	Upper Yakima(Nov.)	95,431	94:0
1984	5-15-48	50,657	Upper Yakima	46,858	92.5
1984	5-15-49	51,846	Mary's Pond(H)	47,076	90.8
1984	5-15-50	46,476	Mary's Pond(HxW)	40,434	87.0
1984	5-15-51	33,052	Mary's Pond(WxW)	29,449	89.1
1985	5-17-38 5-17-56	50,113	Upper Yakima	42,796	85.4
1985	5-17-38 5-17-56	50,519	Mary's Pond(H)	44,436	84.8
1985	5-17-55	52,392	Mary's Pond(HxW)	44,899	85.7
1985	5-14-46,47,48	56,841	Mary's Pond(WxW)	47,576	83.7

Table 26. Estimated expanded returns of hatchery released smolts.

Tag code	Source of recovery [a]	Number recovered	Sample rate	Sample expanded	Mark rate	Total recovery
5-15-32	4	1	1.00	2	.958	2
5-15-46	4	6	1.00	21	.940	23
5-15-47	4	5	1.00	18	.940	I2
5-E-48	4	3	1.00	22	.925	23
5-15-49	4	3	1.00	28	.908	29
5-17-38	4	25	1.00	24	.854	26
5-17-55	4	25	1.00	27	.857	29
5-17-56	4	33	1.00	6	.848	6
5-E-46	4	17	1.00	14	.837	15
5-15-47	4	25	1.00	6	.837	7

a Recovery code 1 = Zone 6 c[redacted]l and subsistence fishery; 2 = Yakima River dipnet fishery; 3 = Naches spawner and carcass surveys; 4 = Yakima River Roza fish trap; 5=Rattlesnake Creek spawner surveys.

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APPENDIX A.

Prosser Dam adult spring chinook counts for
April, 1989

Prosser Dam adult spring chinook counts for
May 1.989

Prosser Dam adult spring chinook counts for
June, 1989

Prosser Dam adult spring chinook counts for
July, 1989

Prosser Dam adult spring chinook counts for
August, 1989

Appendix Table A.1. Prosser Dam adult spr .ng chinook counts for April, 1989.

	DAILY				CUMULATIVE			
DATE	WCKJ	WCKA	HCKJ	HCKA	WCKJ	WCKA	HCKJ	HCKA
01-Apr	0	0	0	0	0	0	0	0
02-Apr	0	0	0	0	0	0	0	0
03-Apr	0	0	0	0	0	0	0	0
04-Apr	0	0	0	0	0	0	0	0
05-Apr	0	0	0	0	0	0	0	0
06-Apr	0	0	0	0	0	0	0	0
07-Apr	0	0	0	0	0	0	0	0
Od-Apr	0	0	0	0	0	0	0	0
09-Apr	0	0	0	0	0	0	0	0
10-Apr	0	0	0	0	0	0	0	0
11-Apr	0	0	0	0	0	0	0	0
12-Apr	0	0	0	0	0	0	0	0
13-Apr	0	0	0	0	0	0	0	0
14-Apr	0	0	0	0	0	0	0	0
15-Apr	0	0	0	0	0	0	0	0
16-Apr	0	1	0	0	0	1	0	0
17-Apr	0	0	0	0	0	1	0	0
18-Apr	0	0	0	0	0	1	0	0
19-Apr	0	0	0	0	0	1	0	0
20-Apr	0	0	0	0	0	1	0	0
21-Apr	0	1	0	0	0	2	0	0
22-Apr	0	1	0	0	0	3	0	0
23-Apr	0	2	0	0	0	5	0	0
24-Apr	0	5	0	0	0	10	0	0
25-Apr	0	10	0	1	0	20	0	1
26-Apr	0	13	0	2	0	33	0	3
27-Apr	0	46	0	0	0	79	0	3
28-Apr	1	38	0	1	1	117	0	4
29-Apr	2	31	0	4	3	148	0	8
30-Apr	1	32	0	2	4	180	0	10
April Total	4	180	0	10	4	180	0	10

Interpolation on 4/22 thru 4/25.

Appendix Table A.2. Prosser Dam adult spring chinook counts for Hay, 1989.

	DAILY				CUMULATIVE			
DATE	WCKJ	WCKA	ECKJ	HCKA	WCKJ	WCKA	HCKJ	HCKA
01-Hay	1	48	0	2	5	228	0	12
02-May	2	69	0	1	7	297	0	13
03-May	3	93	0	1	10	390	0	14
OQ-Hay	2	106	0	10	12	496	0	24
05-May	0	89	0	9	12	585	0	33
06-May	0	106	0	2	12	691	0	35
07-Hay	3	63	0	1	15	754	0	36
08-May	0	96	0	7	15	850	0	43
09-May	11	74	0	7	26	924	0	50
10-May	1	95	0	9	27	1019	0	59
ll-Hay	3	173	0	8	30	1192	0	67
12-May	3	189	0	7	33	1381	0	74
13-May	0	159	0	13	33	1540	0	87
14-May	4	250	0	6	37	1790	0	93
15-May	5	220	0	11	42	2010	0	104
16-May	8	171	0	3	50	2181	0	107
17-May	8	203	0	7	58	2384	0	114
18-May	9	174	0	12	67	2558	0	126
19-May	4	144	0	8	71	2702	0	134
20-May	6	12	0	2	77	2774	0	136
21-May	11	123	0	4	88	2891	0	140
22-May	13	127	0	a	101	3024	0	148
23-May	18	132	0	5	119	3156	0	153
24-May	18	94	0	8	137	3250	0	161
25-May	10	61	0	0	147	3311	0	161
26-May	10	78	0	3	157	3389	0	164
27-May	7	47	0	3	164	3436	0	167
28-May	9	62	0	2	173	3498	0	169
29-May	7	57	0	2	180	3555	0	171
30-May	5	55	0	1	185	3610	0	172
31-May	6	25	0	3	191	3635	0	175
May Total	187	3455	0	165	191	3635	0	175

Appendix Table A.3. Prosser Dam adult spring chinook counts for June, 1989.

	DAILY				CUMULATIVE			
DATE	WCKJ	WCKA	HCKJ	HCKA	WCKJ	WCKA	ACKJ	HCKA
01-Jun	2	32	0	0	193	3667	0	175
02-Jun	5	37	0	1	198	3704	0	176
03-Jun	12	33	0	0	210	3737	0	176
04-Jun	5	15	0	0	215	3752	0	176
05-Jun	6	7	0	1	221	3759	0	177
06-Jun	0	10	0	1	221	3769	0	178
07-Jun	0	8	0	0	221	3777	0	178
08-Jun	0	7	0	0	221	3784	0	178
09-Jun	0	5	0	1	221	3789	0	179
10-Jun	0	3	0	0	221	3792	0	179
ll-Jun	0	3	0	0	221	3795	0	179
12-Jun	1	10	0	0	222	3805	0	179
13-Jun	3	9	0	1	225	3814	0	180
14-Jun	0	1	0	1	225	3815	0	181
15-Jun	0	3	0	1	225	3818	0	182
16-Jun	3	17	0	3	228	3835	0	185
17-Jun	3	19	0	3	231	3854	0	188
18-Jun	1	14	0	0	232	3868	0	188
19-Jun	0	4	0	0	232	3812	0	188
20-Jun	1	12	0	0	233	3884	0	188
21-Jun	1	5	0	1	234	3889	0	189
22-Jun	0	7	0	0	234	3896	0	189
23-Jun	1	1	0	0	235	3897	0	189
24-Jun	1	0	0	0	236	3897	0	189
25-Jun	0	1	0	0	236	3898	0	189
26-Jun	0	2	0	0	236	3900	0	189
27-Jun	1	0	0	0	237	3900	0	189
28-Jun	0	0	0	0	237	3900	0	189
29-Jun	0	0	0	0	237	3900	0	189
30-Jun	0	2	0	1	237	3902	0	190
June Total	46	267	0	15	237	3902	0	190

Interpolation on 6/15 thru 6/17.

Appendix Table A.4. Prosser Dam adult spring chinook counts for July, 1989.

	DAILY				CUMULATIVE			
DATE	WCKJ	WCKA	HCKJ	HCKA	WCKJ	WCKA	HCKJ	HCKA
01-Jul	1	0	0	2	238	3902	0	192
02-Jul	0	0	0	0	238	3902	0	192
03-Jul	0	5	0	0	238	3907	0	192
04-Jul	2	2	0	0	240	3909	0	192
05-Jul	0	1	0	1	240	3910	0	193
06-Jul	0	2	0	1	240	3912	0	194
07-Jul	2	0	0	0	242	3912	0	194
08-Jul	0	3	0	0	242	3915	0	194
09-Jul	1	1	0	0	243	3916	0	194
10-Jul	0	0	0	0	243	3916	0	194
11-Jul	1	0	0	0	244	3916	0	194
12-Jul	0	1	0	0	244	3917	0	194
13-Jul	0	0	0	0	244	3917	0	194
14-Jul	0	0	0	0	244	3917	0	194
15-Jul	0	0	0	0	244	3917	0	194
16-Jul	0	0	0	0	244	3917	0	194
17-Jul	0	1	0	0	244	3918	0	194
18-Jul	0	0	0	0	244	3918	0	194
19-Jul	0	1	0	0	244	3919	0	194
20-Jul	0	0	0	0	244	3919	0	194
21-Jul	0	0	0	0	244	3919	0	194
22-Jul	0	0	0	0	244	3919	0	194
23-Jul	0	0	0	0	244	3919	0	194
24-Jul	0	0	0	0	244	3919	0	194
25-Jul	0	0	0	0	244	3919	0	194
26-Jul	0	0	0	0	244	3919	0	194
27-Jul	0	0	0	0	244	3919	0	194
28-Jul	0	0	0	0	244	3919	0	194
29-Jul	0	0	0	0	244	3919	0	194
30-Jul	0	0	0	0	244	3919	0	194
31-Jul	0	0	0	0	244	3919	0	194
July Total	7	17	0	4	244	3919	0	194

Appendix Table A.5. Prosser Dam adult spring chinook counts for August, 1989.

	DAILY				CUMULATIVE			
DATE	WCKJ	WCKA	HCKJ	HCKA	WCKJ	WCKA	HCKJ	HCKA
01-Aug	0	0	0	0	244	3919	0	194
02-Aug	0	0	0	0	244	3919	0	194
03-Aug	0	0	0	0	244	3919	0	194
04-Aug	0	2	0	0	244	3921	0	194
05-Aug	0	0	0	0	244	3921	0	194
06-Aug	0	0	0	0	244	3921	0	194
07-Auq	0	0	0	0	244	3921	0	194
08-Aug	0	0	0	0	244	3921	0	194
09-Aug	0	0	0	0	244	3921	0	194
10-Aug	0	0	0	0	244	3921	0	194
11-Aug	0	0	0	0	244	3921	0	194
12-Aug	0	0	0	0	244	3921	0	194
13-Aug	0	0	0	0	244	3921	0	194
14-Aug	0	0	0	0	244	3921	0	194
15-Aug	0	0	0	0	244	3921	0	194
Aug Total	0	2	0	0	244	3921	0	194

APPENDIX B.

Roza Dam adult spring chinook counts for
May, 1989

Roza Dam adult spring chinook counts for
June, 1989

Roza Dam adult spring chinook counts for
July, 1989

Roza Dam adult spring chinook counts for
August, 1989

Roza Dam adult spring chinook counts for
September, 1989

Appendix Table B.1. Roza Dam adult spring chinook counts for Hay, 1989.

	DAILY				CUMULATIVE			
DATE	WCKJ	WCKA	HCKJ	HCKA	WCKJ	WCKA	HCKJ	HCKA
01-Bay	0	0	0	0	0	0	0	0
02-May	0	0	0	0	0	0	0	0
03-May	0	6	0	0	0	6	0	0
04-May	0	3	0	1	0	9	0	1
05-May	0	4	0	0	0	13	0	1
06-May	0	9	0	1	0	22	0	2
07-May	0	16	0	3	0	38	0	5
08-May	0	0	0	0	0	38	0	5
09-May	0	11	0	1	0	49	0	6
10-May	0	0	0	0	0	49	0	6
11-Hay	0	2	0	0	0	51	0	6
12-May	1	1	0	0	1	52	0	6
13-May	0	1	0	1	1	53	0	7
14-May	0	23	0	4	1	76	0	11
15-May	0	54	0	5	1	130	0	16
16-May	0	141	0	13	1	271	0	29
17-May	0	59	0	5	1	330	0	34
18-May	0	26	0	3	1	356	0	37
19-May	0	34	0	11	1	390	0	48
20-May	0	45	0	3	1	435	0	51
21-May	1	91	0	3	2	526	0	54
22-May	0	110	0	5	2	636	0	59
23-May	0	142	0	8	2	778	0	67
24-May	3	113	0	9	5	891	0	76
25-May	0	111	0	10	5	1002	0	86
26-Hay	1	107	0	2	6	1109	0	88
27-May	1	53	0	2	7	1162	0	90
28-May	0	68	0	5	7	1230	0	95
29-May	0	74	0	8	7	1304	0	103
30-May	1	127	0	5	8	1431	0	108
31-May	3	184	0	7	11	1615	0	115
May Total	11	1615	0	115	11	1615	0	115

Appendix Table B.2. Roza Dam adult spring chinook counts for June, 1989.

	DAILY				CUMULATIVE			
DATE	WCKJ	WCKA	HCKJ	HCKA	WCKJ	WCKA	HCKJ	HCKA
01-Jun	9	130	0	5	20	1745	0	120
02-Jun	1	43	0	7	21	1788	0	127
03-Jun	11	151	0	8	32	1939	0	135
04-Jun	1	58	0	5	33	1997	0	140
05-Jun	3	122	0	4	36	2119	0	144
06-Jun	0	57	0	6	36	2176	0	150
07-Jun	2	75	0	4	38	2251	0	154
08-Jun	0	49	0	6	38	2300	0	160
09-Jun	1	47	0	5	39	2347	0	165
10-Jun	4	41	0	2	43	2388	0	167
11-Jun	7	90	0	8	50	2478	0	175
12-Jun	1	93	0	5	51	2571	0	180
13-Jun	4	77	0	3	55	2648	0	183
14-Jun	0	28	0	0	55	2676	0	183
15-Jun	1	12	0	2	56	2688	0	185
16-Jun	0	5	0	1	56	2693	0	186
17-Jun	3	21	0	9	59	2714	0	195
18-Jun	0	3	0	3	59	2717	0	198
19-Jun	0	12	0	0	59	2729	0	198
20-Jun	1	26	0	1	60	2755	0	199
21-Jun	0	20	0	6	60	2775	0	205
22-Jun	2	26	0	5	62	2801	0	210
23-Jun	0	11	0	0	62	2812	0	210
24-Jun	4	21	0	1	66	2833	0	211
25-Jun	2	14	0	2	68	2847	0	213
26-Jun	12	36	0	0	80	2883	0	213
27-Jun	1	10	0	0	81	2893	0	213
28-Jun	0	5	0	1	81	2898	0	214
29-Jun	2	23	0	1	83	2921	0	215
30-Jun	0	4	0	1	83	2925	0	216
June Total	72	1310	0	101	83	2925	0	216

Appendix Table B.3. Roza Dam adult spring chinook counts for July, 1989.

	DAILY				CUMULATIVE			
DATE	WCKJ	WCKA	HCKJ	HCKA	WCKJ	WCKA	ECKJ	HCKA
01-Jul	0	8	0	0	83	2933	0	216
02-Jul	3	12	0	0	86	2945	0	216
03-Jul	3	16	0	2	89	2961	0	218
04-Jul	0	6	0	0	89	2967	0	218
05-Jul	1	3	0	0	90	2970	0	218
06-Jul	2	4	0	0	92	2974	0	218
07-Jul	2	3	0	1	94	2977	0	219
08-Jul	0	1	0	0	94	2978	0	219
09-Jul	1	6	0	0	95	2984	0	219
10-Jul	0	3	0	0	95	2987	0	219
11-Jul	2	7	0	0	97	2994	0	219
12-Jul	4	16	0	0	101	3010	0	219
13-Jul	5	13	0	0	106	3023	0	219
14-Jul	0	4	0	0	106	3027	0	219
15-Jul	0	5	0	0	106	3032	0	219
16-Jul	0	0	0	0	106	3032	0	219
17-Jul	3	7	0	0	109	3039	0	219
18-Jul	3	9	0	0	112	3048	0	219
19-Jul	3	13	0	0	115	3061	0	219
20-Jul	3	16	0	1	118	3077	0	220
21-Jul	3	7	0	0	121	3084	0	220
22-Jul	3	5	0	0	124	3089	0	220
23-Jul	1	2	0	1	125	3091	0	221
24-Jul	2	11	0	0	127	3102	0	221
25-Jul	2	8	0	0	129	3110	0	221
26-Jul	0	5	0	0	129	3115	0	221
27-Jul	6	12	0	0	135	3127	0	221
28-Jul	0	2	0	0	135	3129	0	221
29-Jul	0	0	0	0	135	3129	0	221
30-Jul	3	4	0	0	138	3133	0	221
31-Jul	2	13	0	2	140	3146	0	223
July Total	57	221	0	7	140	3146	0	223

Interpolation on 7/19.

Appendix Table B.4. Roza Dam adult spring chinook counts for August, 1989.

	DAILY				CUMULATIVE			
DATE	WCKJ	WCKA	HCKJ	HCKA	WCKJ	WCKA	HCKJ	HCKA
01-Auq	4	7	0	0	144	3153	0	223
02-Auq	8	20	0	0	152	3173	0	223
03-Auq	0	4	0	0	152	3177	0	223
04-Auq	0	2	0	1	152	3179	0	224
05-Aug	0	2	0	0	152	3181	0	224
06-Auq	3	4	0	0	155	3185	0	224
07-Auq	4	9	0	0	159	3194	0	224
08-Aug	4	14	0	0	163	3208	0	224
09-Aug	0	4	0	0	163	3212	0	224
10-Aug	0	1	0	0	163	3213	0	224
11-Auq	0	0	0	0	163	3213	0	224
12-Aug	0	2	0	0	163	3215	0	224
13-Aug	2	3	0	0	165	3218	0	224
14-Aug	5	4	0	0	170	3222	0	224
15-Auq	4	4	0	0	174	3226	0	224
16-Aug	0	0	0	0	174	3226	0	224
17-Aug	0	0	0	0	174	3226	0	224
18-Aug	0	0	0	0	174	3226	0	224
19-Aug	1	7	0	0	175	3233	0	224
20-Auq	2	4	0	0	177	3237	0	224
21-Auq	5	7	0	0	182	3244	0	224
22-Aug	4	4	0	0	186	3248	0	224
23-Auq	2	4	0	3	188	3252	0	227
24-Aug	0	1	0	0	188	3253	0	227
25-Aug	0	4	0	2	188	3257	0	229
26-Aug	0	0	0	0	188	3257	0	229
27-Auq	3	3	0	0	191	3260	0	229
28-Aug	0	6	0	3	191	3266	0	232
29-Auq	0	0	0	0	191	3266	0	232
30-Auq	3	2	0	0	194	3268	0	232
31-Auq	0	2	0	0	194	3270	0	232
Aug Total	54	124	0	9	194	3270	0	232

Appendix Table B.5. Roza Dam adult spring chinook counts for September, 1989.

	DAILY				CUMULATIVE			
DATE	WCKJ	WCKA	HCKJ	HCKA	WCKJ	WCKA	HCKJ	HCKA
01-Sep	0	0	0	0	194	3270	0	232
02-Sep	0	0	0	0	194	3270	0	232
03-Sep	4	3	0	0	198	3273	0	232
04-Sep	0	0	0	0	198	3273	0	232
05-Sep	5	4	0	0	203	3277	0	232
06-Sep	1	5	0	0	204	3282	0	232
07-Sep	0	0	0	0	204	3282	0	232
08-Sep	0	1	0	1	204	3283	0	233
09-Sep	0	0	0	0	204	3283	0	233
10-Sep	2	5	0	0	206	3288	0	233
11-Sep	1	3	0	1	207	3291	0	234
12-Sep	1	3	0	1	208	3294	0	235
13-Sep	0	0	0	0	208	3294	0	235
14-Sep	0	0	0	0	208	3294	0	235
15-Sep	0	0	0	0	208	3294	0	235
16-Sep	0	0	0	0	208	3294	0	235
17-Sep	1	6	0	0	209	3300	0	235
18-Sep	0	4	0	0	209	3304	0	235
19-Sep	1	0	0	0	210	3304	0	235
20-Sep	0	7	0	1	210	3311	0	236
21-Sep	0	0	0	0	210	3311	0	236
22-Sep	0	0	0	0	210	3311	0	236
23-Sep	0	0	0	0	210	3311	0	236
24-Sep	1	5	0	0	211	3316	0	236
25-Sep	0	5	0	0	211	3321	0	236
26-Sep	0	0	0	0	211	3321	0	236
27-Sep	0	4	0	0	211	3325	0	236
28-Sep	0	0	0	0	211	3325	0	236
29-Sep	0	0	0	0	211	3325	0	236
30-Sep	Discontinued trapping.				211	3325	0	236
Sept Total	17	55	0	4	211	3325	0	236

APPENDIX C.

Prosser spring chinook smolt winter outmigration for
November, 1988

Prosser spring chinook smolt winter outmigration for
December, 1988

Prosser spring chinook smolt winter outmigration for
January, 1989

Prosser spring chinook smolt winter outmigration for
February, 1989

Prosser spring chinook smolt winter outmigration for
March, 1989

Prosser spring chinook smolt outmigration for
April, 1989

Prosser spring chinook smolt outmigration for
May, 1989

Prosser spring chinook smolt outmigration for
June, 1989

Prosser spring chinook smolt outmigration for
July, 1989

Appendix Table C.1. Prosser sprinq chinook smolt winter outmiqration for November, 1988.

DATE	CANAL DISCHARGE	RIVER DISCHARGE	P.D.C. %	EFF.	SUB SAMPLE	CATCH CHIN.	PASSAGE CHINOOK	SEASON CUMULATIVE	PERCENT CUMULATIVE
11/23/88	1206.68	457.23	72.52	0.945	1	48	51	51	0.2
11/24/88	1209.47	632.85	65.65	0.902	1	48	53	104	0.5
11/25/88	1216.95	662.23	64.76	0.894	1	125	140	244	1.2
11/26/88	1220.83	561.13	68.51	0.922	1	1010	1095	1339	6.5
11/27/88	1226.07	517.42	70.32	0.933	1	613	657	1996	9.7
11/28/88	1212.88	490.39	71.21	0.938	1	1304	1390	3386	16.4
11/29/88	1287.11	456.98	73.80	0.951	1	636	669	4055	19.6
11/30/88	1371.52	527.22	72.23	0.944	1	644	683	4738	22.9
Nov Total						4428	4738		

Appendix Table C.2. Prosser spring chinook smolt winter outmiqration for December, 1988.

DATE	CANAL DISCHARGE	RIVER DISCHARGE	P.D.C. %	EFF.	SUB SAMPLE	CATCH CHIN.	PASSAGE CHINOOK	SEASON CUMULATIVE	PERCENT CUMULATIVE
12/01/88	1353.11	626.88	68.34	0.921	1	268	291	5029	24.3
12/02/88	1365.76	691.98	66.37	0.907	1	160	176	5205	25.2
12/03/88	1363.47	508.15	72.85	0.946	1	122	129	5334	25.8
12/04/88	1337.44	361.44	78.72	0.968	1	74	77	5411	26.2
12/05/88	1346.21	410.33	76.64	0.961	1	105	109	5520	26.7
12/06/88	1341.26	392.79	77.35	0.964	1	198	205	5725	27.7
12/07/88	1342.27	386.44	77.65	0.965	1	102	106	5831	28.2
12/08/88	1344.65	480.8	73.66	0.950	1	50	53	5884	28.5
12/09/88	1369.43	723.46	65.43	0.900	1	32	36	5920	28.6
12/10/88	1364.84	838.22	61.95	0.867	1	39	45	5965	28.9
12/11/88	1362.23	934.62	59.31	0.837	1	35	42	6007	29.1
12/12/88	1352.41	1051.3	56.26	0.796	1	30	38	6045	29.2
12/13/88	1357.69	1063.52	56.07	0.793	1	215	271	6316	30.6
12/14/88	1367.86	1469.33	48.21	0.651	1	79	121	6437	31.1
12/15/88	1355.96	2291.78	37.17	0.406	1		199	6636	32.1
12/16/88	1292.73	2058.79	38.57	0.437	1		201	6837	33.1
12/17/88	1261.12	1711.41	42.43	0.524	1		204	7041	34.1
12/18/88	883.25	1786.59	33.08	0.320	1		206	7247	35.1
12/19/88	968.08	1533.87	38.69	0.440	1		209	7456	36.1
12/20/88	1056.28	1434.32	42.41	0.524	1		211	7667	37.1
12/21/88	1108.34	1332.04	45.42	0.592	1	200	338	8005	38.7
12/22/88	1173.62	1157.74	50.34	0.694	1	91	131	8136	39.4
12/23/88	1215.14	1040.13	53.88	0.758	1	132	174	8310	40.2
12/24/88	1206.05	966.26	55.52	0.784	1	42	54	8364	40.5
12/25/88	1196.83	879.72	57.64	0.815	1	42	52	8416	40.7
12/26/88	1188.78	799.95	59.78	0.843	1	414	491	8907	43.1
12/27/88	1185.21	646.6	64.70	0.894	1	175	196	9103	44.0
12/28/88	1187.33	513.17	69.82	0.931	1	1376	1479	10582	51.2
12/29/88	1218.69	591.82	67.31	0.914	1	311	340	10922	52.8
12/30/88	1249.97	660.26	65.44	0.900	1	325	361	11283	54.6
12/31/88	1287.81	808.37	61.44	0.862	1	211	245	11528	55.8
Dec Total						4828	6790		

Interpolation on 12/15 - 12/20.

Appendix Table C.3. Prosser spring chinook smolt winter outmiqration for January, 1989.

DATE	CANAL DISCHARGE	RIVER DISCHARGE	P.D.C. %	EFF.	SUB SAMPLE	CATCH CHIN.	PASSAGE CHINOOK	SEASON CUMULATIVE	PERCENT CUMULATIVE
01/01/89	1305.61	1098.04	54.32	0.765	1	212	277	11805	57.1
01/02/89	1280.25	1107.06	53.63	0.754	1	88	117	11922	57.7
01/03/89	1290.69	1021.92	55.81	0.789	1	244	309	12231	59.2
01/04/89	1299.39	921.91	58.50	0.827	1	404	489	12720	61.5
01/05/89	1305.56	1034.86	55.78	0.788	1		373	13093	63.3
01/06/89	1316.59	1205.68	52.20	0.729	1		258	13351	64.6
01/07/89	1316.64	1189.54	52.54	0.735	1	104	142	13493	65.3
01/08/89	1295.21	1103.29	54.00	0.760	1	209	275	13768	66.6
01/09/89	1304.30	957.36	57.67	0.816	1	205	251	14019	67.8
01/10/89	1301.04	952.76	57.73	0.816	1	167	205	14224	68.8
01/11/89	1311.55	984.43	57.12	0.808	1	163	202	14426	69.8
01/12/89	1327.30	922.51	59.00	0.833	1	39	47	14473	70.0
01/13/89	1326.93	868.35	60.44	0.851	1	88	103	14576	70.5
01/14/89	1336.28	780.61	63.12	0.879	1	139	158	14734	71.3
01/15/89	1346.46	745.31	64.37	0.891	1	155	174	14908	72.1
01/16/89	1340.71	706.08	65.50	0.900	1	97	108	15016	72.6
01/17/89	1330.28	662.21	66.76	0.910	1	46	51	15067	72.9
01/18/89	1350.91	768.35	63.74	0.885	1	15	17	15084	73.0
01/19/89	1367.49	1075.19	55.98	0.791	1	29	37	15121	73.1
01/20/89	1367.85	1343.38	50.45	0.696	1	31	45	15166	73.4
01/21/89	1354.78	1405.95	49.07	0.669	1	16	24	15190	73.5
01/22/89	1341.84	1298.17	50.83	0.703	1	14	20	15210	73.6
01/23/89	1334.71	1180.69	53.06	0.744	1	78	105	15315	74.1
01/24/89	1327.63	1062.34	55.55	0.785	1	75	96	15411	74.6
01/25/89	1327.00	890.6	59.84	0.844	1	149	177	15588	75.4
01/26/89	1349.65	859.97	61.08	0.858	1	104	121	15709	76.0
01/27/89	1353.04	807.22	62.63	0.874	1	101	116	15825	76.6
01/28/89	1357.39	759.26	64.13	0.889	1	46	52	15877	76.8
01/29/89	1359.92	714.14	65.57	0.901	1	86	96	15973	77.3
01/30/89	1362.46	665.42	67.19	0.913	1	49	54	16027	77.5
01/31/89	1351.56	748.77	64.35	0.891	1	6	7	16034	77.6
Jan Total						3159	4506		

Interpolation on 1/5 and 1/6.

Appendix Table C-4. Prosser spring chinook smolt winter outmiqration for February, 1989.

DATE	CANAL DISCHARGE	RIVER DISCHARGE	P.D.C. %	EFF.	SUB SAMPLE	CATCH CHIN.	PASSAGE CHINOOK	SEASON CUMULATIVE	PERCENT CUMULATIVE
02/01/89	1361.05	1801.57	43.04	0.538	1	0	0	16034	77.6
02/02/89	724.4	2649.75	21.47	0.140	1		3	16037	77.6
02/03/89	43	2303.82	1.83	0.026	1		3	16040	77.6
02/04/89	43	2217.27	1.90	0.027	1		3	16043	77.6
02/05J89	43	2015.48	2.09	0.027	1		2	16045	77.6
02/06/89	43	2054.86	2.05	0.027	1		2	16047	77.6
02/07/89	43	2192.52	1.92	0.027	1		2	16049	77.6
02/08/89	43	2147.86	1.96	0.027	1		2	16051	77.6
02/09/89	43	2091.73	2.01	0.027	1		2	16053	77.7
02/10/89	43	2095.01	2.01	0.027	1		2	16055	77.7
02/11/89	43	2124.07	1.98	0.027	1		2	16057	77.7
02/12/89	43	2214.31	1.90	0.027	1		1	16058	77.7
02/13/89	43	2236.41	1.89	0.027	1		1	16059	77.7
02/14J89	43	2058.7	2.05	0.027	1		1	16060	77.7
02/15/89	63.55	1980.66	3.11	0.030	1		1	16061	77.7
02/16/89	77.45	1981.1	3.76	0.031	1		1	16062	77.7
02/17/89	91.53	1907.26	4.58	0.034	1		1	16063	77.7
02/18/89	136.31	1762.03	7.18	0.042	1		1	16064	77.7
02/19/89	151.5	1607.08	8.61	0.048	1		0	16064	77.7
02/20J89	151	1601.22	8.62	0.048	1		0	16064	77.7
02/21/89	290.73	1452.33	16.68	0.095	1		0	16064	77.7
02/22/89	578.4	1318.03	30.50	0.271	1	0	0	16064	77.7
02/23/89	781.24	1084.05	41.88	0.512	1	27	53	16117	78.0
02/24/89	934.42	919.42	50.40	0,695	1	21	30	16147	78.1
02/25/89	1042.4	727.4	58.90	0.832	1	42	51	16198	78.4
02/26/89	1137.56	656.51	63.41	0.882	1	119	135	16333	79.0
02/27/89	1204.14	623.36	65.90	0.904	1	326	361	16694	80.8
02/28/89	1235.94	536.31	69.74	0.930	1	27	29	16723	80.9
Feb Total						562	689		

Interpolation on 2/2 - 2/22.

Appendix Table C.5. Prosser spring chinook smolt winter outmiqration for March, 1989.

DATE	CANAL DISCHARGE	RIVER DISCHARGE	P.D.C. %	EFF.	SUB SAMPLE	CATCH CHIN.	PASSAGE CHINOOK	SEASON CUMULATIVE	PERCENT CUMULATIVE
03/01/89	1267.55	565.04	69.17	0.927	1	10	11	16734	81.0
03/02/89	1286.62	616.87	67.59	0.916	1	153	167	16901	81.8
03/03/89	1269.43	481.46	72.50	0,945	1	84	89	16990	82.2
03/04/89	1250.17	414.26	75.11	0.956	1	63	66	17056	82.5
03/05/89	1236.3	395.65	75.76	0.958	1	120	125	17181	83.1
03/06/89	1258.43	375.28	77.03	0.963	1	74	[illegible]	17258	83.5
03/07/89	1292.74	566.39	69.53	0.929	1	120	[illegible]	17387	84.1
03/08/89	1228.88	923.79	57.09	0.808	1	63	[illegible]	17465	84.5
03/09/89	1101.55	1040.33	51.43	0.715	1	465	[illegible]	18116	87.6
03/10/89	904.07	1095.64	45.21	0.587	1		[illegible]	18686	90.4
03/11/89	527	2958.47	15.12	0.084	1		490	19176	92.8
03/12/89	152	4774.49	3.09	0.030	1		409	19585	94.7
03/13/89	43	5142.33	0.83	0.024	1		328	19913	96.3
03/14/89	116.86	4941.46	2.31	0.028	1		247	20160	97.5
03/15/89	479.71	3902.78	10.95	0.059	1		167	20327	98.3
03/16/89	740.75	3284.74	18.40	0.110	1		86	20413	98.7
03/17/89	1044.13	2756.84	27.47	0.220	1	1	5	20418	98.8
03/18/89	1259.22	2312.8	35.25	0.364	1	3	8	20426	98.8
03/19/89	1310.35	2127.56	38.11	0.427	1	2	5	20431	98.8
03/20/89	1340.1	1845.08	42.07	0.516	1	2	4	20435	98.9
03/21/89	1369.04	1750.61	43.88	0.557	1	2	4	20439	98.9
03/22/89	1396.74	1704.58	45.04	0.583	1	2	3	20442	98.9
03/23/89	1379.21	2054.45	40.17	0.473	1	3	6	20448	98.9
03/24/89	1414.82	1886.95	42.85	0.534	1	5	9	20457	99.0
03/25/89	1440.34	1736.7	45.34	0.590	1	2	3	20460	99.0
03/26/89	1443.99	1685.27	46.14	0.607	1	6	10	20470	99.0
03/27/89	1457.09	1645.43	46.96	0.625	1	9	14	20484	99.1
03/28/89	1451.26	1440.01	50.19	0.691	1	6	9	20493	99.1
03/29/89	1450.54	1329.87	52.17	0.728	1	37	51	20544	99.4
03/30/89	1446.79	1245.45	53.74	0.756	1	79	105	20649	99.9
03/31/89	1449.9	1299.22	52.74	0.738	1	17	23	20672	100.0
March Total						1328	3949		

Interpolation on 3/10 - 3/16.

Appendix Table C.6. Prosser spring chinook smolt outmigration for April, 1989.

DATE	CANAL DISCHARGE	RIVER DISCHARGE	P.D.C. %	EFF.	SUB SAMPLE	CATCA CHIN	PASSAGE CHIN	SEASON CUMULATIVE	PERCENT CUMULATIVE
04/01/89	1449.84	1239.51	53.91	0.759	1	24	32	32	0.0
04/02/89	1455.69	1169.72	55.45	0.783	1	17	22	54	0.1
04/03/89	1456.58	1147.75	55.93	0.791	1	20	25	79	0.1
04/04/89	1452.53	1045.6	58.14	0.822	1	17	21	100	0.1
04/05/89	1444.05	906.99	61.42	0.862	1	57	66	166	0.2
04/06/89	1442.24	807.48	64.11	0.888	1	45	51	217	0.2
04/07/89	1446.68	2514.49	36.52	0.392	1	1163	2970	3187	3.6
04/08/89	1439.02	5572.97	20.52	0.130	1	1405	10798	13985	15.7
04/09/89	1402.3	5903.96	19.19	0.117	1	411	3513	17498	19.7
04/10/89	1385.77	5227.16	20.96	0.135	1	190	1411	18909	21.2
04/11/89	1395.83	4234.98	24.79	0.181	1	107	592	19501	21.9
04/12/89	1415.83	3823.93	27.02	0.213	1	130	611	20112	22.6
04/13/89	1257.47	4184.36	23.11	0.159	1	189	1187	21299	23.9
04/14/89	1262.07	4497.56	21.91	0.145	1	351	2418	23717	26.6
04/15/89	1285.97	5550.91	18.81	0.113	1	366	3226	26943	30.3
04/16/89	1311.3	7012.72	15.75	0.088	1		2694	29637	33.3
04/17/89	1326.1	7262.39	15.44	0.086	1	186	2162	31799	35.7
04/18/89	1334.42	5871.02	18.52	0.111	1	199	1796	33595	37.7
04/19/89	1354.02	4992.03	21.34	0.139	1	148	1067	34662	38.9
04/20/89	1380.03	5185.45	21.02	0.135	1	279	2061	36723	41.3
04/21/89	1347.37	6422.21	17.34	0.101	1	134	1331	38054	42.8
04/22/89	1336.88	6958.79	16.12	0,091	1	289	3177	41231	46.3
04/23/89	1352.04	6390.36	17.46	0.102	1		2068	43299	48.7
04/24/89	1370.51	5432.19	20.15	0.126	1	121	958	44257	49.7
04/25/89	1383.73	4483.77	23.58	0.165	1	195	1181	45438	51.1
04/26/89	1419.06	3808.32	27.15	0.215	1	200	931	46369	52.1
04/27/89	1442.04	3389.66	29.85	0.259	1	158	609	46978	52.8
04/28/89	1445.97	3071.54	32.01	0.299	1	253	846	47824	53.7
04/29/89	1452.35	2765.52	34.43	0.347	1	652	1878	49702	55.8
04/30/89	1470.01	2461.93	37.39	0.410	1	684	1666	51368	57.7
April Total						7990	51368		

Interpolation on 4/16 and 4/23.

Appendix Table C.7. Prosser spring chinook smolt outmigration for Hay, 1989.

DATE	CANAL DISCHARGE	RIVER DISCHARGE	P.D.C. %	EFF.	SUB SAMPLE	CATCH CHIN	PASSAGE CHIN	SEASON CUHDLATIVE	PERCENT CUHDLATIVE
05/01/89	1459.76	2304.19	38.78	0.442	1	2716	6151	57519	64.6
05/02/89	1449.21	2384.72	37.80	0.420	0.39	309	1888	59407	66.8
05/03/89	1460.3	2454.67	37.30	0.409	0.33	462	3427	62834	70.6
05/04/89	1457.02	2352.88	38.24	0.429	0.48	298	1446	64280	72.2
05/05/89	1449.83	2033.5	41.62	0.506	0.5	528	2087	66367	74.6
05/06/89	1456.84	1962.8	42.60	0.528	0.5	252	954	67321	75.6
05/07/89	1467.86	2407.78	37.87	0.421	0.5	936	4444	71765	80.6
05/08/89	1476.7	3345.88	30.62	0.273	0.66	299	1659	73424	82.5
05/09/89	1475.84	3635.6	28.87	0.243	0.67	265	1630	75054	84.3
05/10/89	1433.46	3544.9	28.79	0.241	0.67	154	953	76007	85.4
05/11/89	1402.47	5432.6	20.52	0.130	0.67	109	1251	77258	86.8
05/12/89	1388.39	6085.79	18.58	0.111	0.67	17	228	77486	87.1
05/13/89	1391.74	5514.73	20.15	0.126	0.67	72	851	78337	88.0
05/14/89	1392.95	4467.96	23.77	0.167	0.94	68	432	78769	88.5
05/15/89	1409.64	3893.52	26.58	0.206	1	188	911	79680	89.5
05/16/89	1398.29	3209.1	30.35	0.268	1	163	608	80288	90.2
05/17/89	1382.7	1817.86	43.20	0.542	1	331	611	80899	90.9
05/18/89	1385.76	1241.98	52.74	0.738	1	154	209	81108	91.1
05/19/89	1374.45	1041.04	56.90	0.805	1	220	273	81381	91.4
05/20/89	1374.92	909.66	60.18	0.848	1	266	314	81695	91.8
05/21/89	1376.94	740.86	65.02	0.896	1	138	154	81849	92.0
05/22/89	1375.1	616.77	69.04	0.926	1	188	203	82052	92.2
05/23/89	1387.74	620.21	69.11	0.926	1	187	202	82254	92.4
05/24/89	1411.65	682.85	67.40	0.915	1	77	84	82338	92.5
05/25/89	1414.35	794.8	64.02	0.888	1	165	186	82524	92.7
05/26/89	1386.1	652.33	68.00	0.919	1	144	157	82681	92.9
05/27/89	1374.45	548.64	71.47	0.940	1	211	225	82906	93.2
05/28/89	1404.36	774.01	64.47	0.892	1	97	109	83015	93.3
05/29/89	1417.85	915.46	60.77	0.854	1	73	85	83100	93.4
05/30/89	1417.92	922.83	60.58	0.852	1	128	150	83250	93.5
05/31/89	1404.78	779.01	64.33	0.890	1	392	440	83690	94.0
May Total						9607	32322		

Appendix Table C.9. Prosser spring chinook smolt outmiqration for July, 1989.

DATE	CANAL DISCHARGE	RIVER DISCHARGE	P.D.C. %	EFF.	SUB SAMPLE	CATCH CHIN	PASSAGE CHIN	SEASON CUHULATIVE	PERCENT CUHULATIVE
07/01/89	1412.9	460.75	75.41	0.957	1	1	1	88987	100.0
07/02 /89	1414.36	478.09	74.74	0,955	1	2	2	88989	100.0
07/03/89	1417.23	461.31	75.44	0.957	1	2	2	88991	100.0
07/04/89	1404.11	399.41	77.85	0.965	1	1	1	88992	100.0
07/05/89	1381.41	306.17	81.86	0.976	1	2	2	88994	100.0
07/06/89	1382.25	294.98	82.41	0.977	1	1	1	88995	100.0
07/07/89	1383.2	285.83	82.87	0.978	1	1	1	88996	100.0
07/08/89	1351.84	247.42	84.53	0.981	1	0	0	88996	100.0
07/09/89	1340.51	243.25	84.64	0.981	1	0	0	88996	100.0
07/10/89	1355.33	255.28	84.15	0.980	1	0	0	88996	100.0
07/11/89	1344.91	254.96	84.06	0.980	1	0	0	88996	100.0
07/12/89	1281.86	226.01	85.01	0.982	1	0	0	88996	100.0
07/13/89	1180.38	193.97	85.89	0.983	1	0	0	88996	100.0
July Total						10	10		

Appendix Table C.8. Prosser spring chinook smolt outmigration for June, 1989.

DATE	CANAL DISCHARGE	RIVER DISCHARGE	P.D.C. %	EFF.	SUB SAMPLE	CATCH CHIN	PASSAGE CHIN	SEASON CUMULATIVE	PERCENT CUMULATIVE
06/01/89	1377.88	545.7	71.63	0.941	1	118	126	83816	94.2
06/02/89	1391.07	584.76	70.40	0.934	1	965	1033	84849	95.3
06/03/89	1386.61	751.45	64.85	0.895	1	2251	2515	87364	98.2
06/04/89	1329.63	847.16	61.08	0.858	0.42	10	28	87392	98.2
06/05/89	1353.17	854.05	61.31	0.860	0.33	3	11	87403	98.2
06/06/89	1389.14	952.91	59.31	0.837	0.33	25	91	87494	98.3
06/07/89	1415.72	1043.18	57.58	0.814	0.33	176	655	88149	99.0
06/08/89	1453.78	1252.81	53.71	0.755	0.33	82	329	88478	99.4
06/09/89	1452.07	1184.99	55.06	0.777	0.33	23	90	88568	99.5
06/10/89	1417.11	846.32	62.61	0.874	0.49	13	30	88598	99.6
06/11/89	1390.61	667.18	67.58	0.916	0.5	45	98	88696	99.7
06/12/89	1403.13	765.58	64.70	0.894	0.5	3	7	88703	99.7
06/13/89	1426.23	945.25	60.14	0.847	0.5	13	31	88734	99.7
06/14/89	1421.7	1008.69	58.50	0.827	0.5	38	92	88826	99.8
06/15/89	1429.53	1169.88	54.99	0.776	0.5	8	21	88847	99.8
06/16/89	1429.23	1254.59	53.25	0.747	0.5	9	24	88871	99.9
06/17/89	1419.14	968.05	59.45	0.839	0.5	4	10	88881	99.9
06/18/89	1404.35	555.81	71.64	0.941	0.5	3	6	88887	99.9
06/19/89	1378.39	302.32	82.01	0.976	0.5	6	12	88899	99.9
06/20/89	1301.8	226.09	85.20	0.982	0.5	4	8	88907	99.9
06/21/89	1297.99	313	80.57	0.973	0.5	9	19	88926	99.9
06/22/89	1334.22	334.71	79.94	0.971	0.96	11	12	88938	99.9
06/23/89	1315.75	263.44	83.32	0.979	1	17	17	88955	100.0
06/24/89	1311.22	267.01	83.08	0.978	1	5	5	88960	100.0
06/25/89	1342.04	304.93	81.49	0.975	1	5	5	88965	100.0
06/26/89	1374.74	347.2	79.84	0.971	1	9	9	88974	100.0
06/27/89	1364.38	282.3	82.86	0.978	1	4	4	88978	100.0
06/28/89	1351.47	262.45	83.74	0.979	1	4	4	88982	100.0
06/29/89	1339.78	247.73	84.40	0.981	1	3	3	88985	100.0
06/30/89	1369.05	300.05	82.02	0.976	1	1	1	88986	100.0
June Total						3867	5296		